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A BOTANICAL STUDY OF PASTURE MIXTURES[1]

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INTRODUCTION

In 1931 a number of pasture mixtures, including biennial and perennial species, were seeded on the Animal Husbandry Farm at the University of Alberta, chiefly with a view to supplying good pasturage for cattle and horses for several years. The mixtures were determined more or less empirically, since little exact knowledge was available regarding the behavior of specific grasses and legumes in association with one another, when grown under Edmonton climatic and soil conditions. Considerable variety was introduced into the mixtures with a view to providing an opportunity for some rather careful studies over a number of years regarding the changes in vegetative composition, relative survival of different species, relative yield of pasturage for different species in mixtures, and possibly other important features, which might lead to conclusions valuable for future use in compounding pasture mixtures for conditions similar to those of the Edmonton district. It was decided to confine attention to six of the mixtures, these appearing to offer best opportunities for studies likely to lead to significant results.

The Department of Animal Husbandry of the University very kindly made possible the observations herein reported, supplied information regarding the field and pasture management of the different pastures, provided materials for the building of enclosures and rendered other encouraging assistance, for all of which the authors wish to express their appreciation.

FIELD AND PASTURE MANAGEMENT

The land on which the pasture mixtures were seeded had previously produced crops as follows:

Pasture A, oats and several crops of sunflowers since breaking in 1922;

Pasture B, rape as well as grains in former years;

Pasture C, grain mixtures, alfalfa, rape and sunflowers in different years;

Pasture D, turnips in 1926, oats from 1926 to 1930;

Pastures E and F, grain mixtures, alfalfa, rape and sunflowers for hog runs in different years up to 1930.

In 1930 all these areas were plowed and thoroughly fallowed to destroy weeds. In the early summer of 1931 the land was cultivated, harrowed and packed in the preparation of a good seed-bed.

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Pasture Mixtures

Table 1 indicates the constituents of each pasture mixture, the amounts of seed used per acre, the dates of seeding and the acreage of each pasture.

TABLE 1.—KINDS AND AMOUNTS OF SEEDS USED IN THE PASTURE MIXTURE

Species	Pastures and pounds of seed used per acre					
	A	B	C	D	E	F
Brome grass	2.8		5.0	2.7		7.0
Crested wheat grass	2.5			2.0	5.0	
Slender wheat grass	0.7	5.0				
Kentucky blue grass	3.0		4.0	4.0	4.0	
Timothy		3.0				
Alfalfa	3.0		5.0		3.0	6.0
Altaswede red clover		4.0				
Alsike clover	2.0	3.0				
White Dutch clover			3.0	5.0	2.0	
Sweet clover	3.0			3.0		
Date of seeding in 1931	June 25 and 26	June 29	July 7	July 8	June 27	June 27
Number of acres	2.8	2.4	1.5	3.0	6.25	6.25

Description of Seeds

The kinds and quality grades of the seeds sown were as follows:

Sweet clover (*Melilotus alba.* Desr.): White blossom, Grade No. 1.

Alfalfa (*Medicago sativa* L.): Grimm, Grade No. 1.

Altaswede red clover (*Trifolium pratense* L.): Certified, Grade No. 1.

Alsike clover (*Trifolium hybridum* L.): Certified, Grade No. 1.

White Dutch clover (*Trifolium repens* L. var. *sylvestre*, race, *hollandicum*): Certified, Grade No. 1.

Brome grass (*Bromus inermis* Leyss.): Certified couch-free, Grade No.1

Kentucky blue grass (*Poa pratensis* L.): Grade No. 1.

Timothy (Phleum pratense L.): Grade No. 1.

Slender wheat grass (*Agropyron tenerum* Vasey): Certified couch-free, Grade No. 1.

Crested wheat grass (*Agropyron cristatum* Gaertn.) (unimproved strain) Certified couch-free, Grade No. 1.

The seeds were purchased in Edmonton, Alberta, from reputable seed firms.

Method of Seeding

The small seeds (sweet clover, alsike clover, Altasweede red clover, white Dutch clover, alfalfa, Kentucky blue grass and timothy) were mixed and then seeded through a grass seeder attachment on the front of a disc grain drill, the seeds falling into the shallow furrows made by the discs. The larger seeds were sown broadcast by hand and covered by harrowing. All the pastures except one were seeded in one direction only. Pasture B, however, was seeded in two directions at right angles to each other.

Post-seeding Management

Pasturing management for all six pastures was under the direction of the Department of Animal Husbandry. No formal nor inflexible system was practised. Weedy patches in some pastures were mowed at intervals the first season to prevent re-seeding of the weeds and smothering of the crop seedlings. All pastures, except D, were grazed by cattle the first fall because of the excessive growth during an unusually moist season. In 1932 grazing was commenced the last week in May on all the pastures and continued throughout the season, except pastures C and D, which were cut for hay the second week in July, and thereafter pastured until fall; and pasture A, which was rested for two weeks in July. Pastures C and D after cutting were grazed by cattle and by sheep respectively. Pasture A, after the July rest period, was cut for hay and then pastured by cattle. In 1933 all the pastures were grazed continuously from the last week in May until fall, pastures A, B, C and E by cattle, and D by brood mares and colts. Similarly in 1934 all the pastures were grazed continuously by cattle from about the middle of May until fall. No other treatments were given these pastures, except in the case of pastures B and D, which were top-dressed with barnyard manure in the summer of 1934.

METHODS

Methods were devised for studying the pastures with respect to changes in botanical composition, the relative survival of species in particular combinations, the extent of winter killing, the productivity of different mixtures and species, and the suppressive action of the various pastures on weeds.

In order to follow the changes in the botanical composition of the pasture sward, counts were made of plants of each species found in 12 systematically distributed strip-areas six feet long by two inches wide marked off in each pasture (Figure 1). Four similar strips were also marked off within each of three seventeen-feet square fenced enclosures (Figure 2) located in each pasture, to serve as checks on those in the grazed areas. To delimit the strip-area to be analysed a strong cord was stretched along both sides of it and drawn taut around the stakes shown in Figure 1. Plants occurring half or more on the inner sides of the cord were included in the count. The unit of vegetation on which the counts were based was a distinct plant possessing an independent root system, as nearly as this could be determined without actually lifting the plant. Difficulty was encountered in the second, third and fourth years in distinguishing individual plants from new tillers in the case of the turf-forming species. In some cases, for this reason, it was found necessary to make an approximate rather than an accurate count of the number of plants present. The results indicate that this method of procedure was sound.

Counts were made the first fall on all the pastures except B, where the plants were too severely trampled by livestock and too dry for positive identification. Three such counts were made in 1932—spring, summer, and fall. In 1933 due to uncontrollable circumstances two counts only were made, one in the spring and one in the fall. Two counts were also made at about the same times in 1934. It was hoped originally that the counts could be made at approximately the same dates each year, but this proved impossible owing to inclement weather and pressure of other work.

It was the intention to analyze the check strip-areas in the enclosures without disturbing the growth on them, but this was found to be impracticable after the first count in the spring due to the rankness of the growth. Consequently, it was found necessary to cut these areas prior to the time of counting. This was usually done when the yield cuts were made. The method of botanical analysis used was a modification of similar methods employed by Davies (*2*) at Aberystwyth, and Hein and Vinall (*7*) in Maryland.

The data were treated statistically and compiled into suitable tables indicating the botanical changes in the vegetation. The variability in the counts due to errors in sampling was measured by computing the standard error of the mean, using Hayes' "Deviation of the Mean Method" (*6*) and Camp's (*1*) formula: Standard Error of the Mean equals $\sqrt{\frac{\Sigma(X-\bar{X})^2}{n(N-1)}}$.

To determine the productivity of the pastures under investigation small areas six feet square within the enclosures (Figure 2) were cut at intervals during the seasons. Two such cuttings were made in 1932 and three in 1933 and in 1934. The dates of cutting were somewhat irregular due to weather conditions and other circumstances. The yield per acre of air-dried herbage for each pasture was computed on the basis of the weight of the green material cut from the six-feet-square areas and a two-pound composite sample made by combining equal random samples taken from the three lots of green herbage. The composite samples were air-dried at room temperature in the laboratory to approximately constant weights.

No attempt was made to compute standard errors for the yield results, as replication of the enclosures was considered insufficient to justify such treatment.

The percentages of leguminous and gramineous herbage present in the stands were determined by taking a one-pound composite sample from the herbage cut from each six-feet-square area. Small air-tight metal cans were used to transport the samples to the laboratory for analysis. The two kinds of herbage and the weeds were separated and weighed while still green, and their percentages of the whole determined. No attempt was made to separate and weigh the amount of each species present on account of the difficulty of identifying small bits of vegetation and the tremendous amount of work involved. The percentages of the more abundant species were merely estimated. This was done by spreading out each sample thinly on a long table, making a rough separation of the various species and estimating the percentage of each species by visual impressions. It was hoped by this method to obtain some idea of the relative productivity of the more important species in the mixtures. This method was employed successfully by certain European workers, notably Davies (*2*).

Seasonal growth of plants was studied by means of height measurements in the spring, again before the livestock were "turned in" in May, and just previous to each cutting in the enclosures. It was thought that data procured in this way would show differences in earliness and rapidity of growth of the different species.

Notes were also taken, both in the spring and in the fall, on such items as general appearance and density of the pasture sward; palatability, as indicated by evenness and closeness of grazing; the prevalence or absence

of bare and trampled-out areas; the presence or absence of weeds; regenerative power, rapidity and earliness of growth; and apparent drought resistance and winterhardiness of the constituent species. These notes were supplemented by photographs taken to show the unevenness of grazing and vigor of growth of plants.

REVIEW OF METEOROLOGICAL DATA

Precipitation

A general impression of the precipitation month by month for the period of observations may be had from the data in Table 2. These data were collected by the Department of Field Crops of the University on the Field Crops Farm, situated about two miles from the location of the pasture plots.

TABLE 2.—PRECIPITATION IN INCHES AT EDMONTON* DURING 1931–1934

Year	Jan.†	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Totals
1931	0	0	1.25	0.44	1.93	6.60	3.53	4.47	0.70	0.97	0.75	0.95	21.59
1932	0.55	0.82	0.83	2.53	1.59	2.27	2.24	0.58	0.89	0.32	1.57	0.63	14.82
1933	0.45	0.74	1.93	0.66	2.05	3.32	3.03	1.30	2.07	1.69	0.98	2.85	21.07
1934	0.76	0.55	1.06	1.55	2.56	3.04	2.67	1.74	‡				

*Measurements of precipitation were made on the Field Crops Farm, two miles from the location of the pasture plots.
†The snowfall data for the winter months were converted into rainfall data by dividing the former by 10.
‡Observations were concluded at the end of September, 1934.

Temperature

The temperature conditions during the four years of the investigation were not unusually extreme, except in January, February, March and December of 1932 and 1933. The lowest Fahrenheit temperatures (atmosphere above the snow cover) reached during these months were, in 1932, −47°, −42°, −34° and −19°; in 1933, −19°, −30°, −23° and −40°; and in 1934, −26°, −23° and −5°, for January, February and March respectively. The temperature data presented in Table 3 were also obtained from the records of the Department of Field Crops of the University.

Weather conditions were particularly favorable from the time of seeding to the end of the first summer, and also the following spring and early summer, but thereafter rainfall was exceptionally deficient. The drought period occurring each year, except 1931, in the latter part of the summer, interfered considerably with the normal seasonal growth.

EXPERIMENTAL RESULTS

Changes in Botanical Composition

The data obtained by frequency counts of plants of various species have been averaged and the respective standard errors computed. The percentage frequency of each species has also been calculated. The results are given in Tables 4 to 9. Table 9 contains data obtained from studies of Pasture F for the fall of 1931 and the spring of 1932 only, as no further counts were made on this pasture because a part of it was destroyed by discing for the purpose of eradicating stinkweed and Canada thistle.

TABLE 3.—MINIMUM MONTHLY AND AVERAGE MONTHLY ATMOSPHERIC TEMPERATURES (FAHRENHEIT) AT EDMONTON DURING 1931, 1932, 1933 AND 1934

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1931												
Minimum	−9	+6	−30	+16	+27	+30	+40	+40	+28	+18	−18	−19
Date of occurrence	13	8	11	20	19	4	2	9	17	27	15	9
Average daily maximum temperature	31.2	40.2	28.6	56.1	63.7	68.1	72.8	70.8	60.0	54.6	32.0	23.8
Average daily minimum temperature	9.2	19.7	9.4	30.2	38.1	46.4	48.9	47.9	37.6	27.2	9.7	5.9
1932												
Minimum	−47	−42	−34	+24	+31	+34	+40	+29	+33	+5	−14	−23
Date of occurrence	31	1	7	2	15, 25	17	12	31	13, 22	28	14	8
Average daily maximum temperature	15.7	20.3	22.7	50.9	65.2	71.4	71.8	75.8	66.5	44.7	28.7	21.4
Average daily minimum temperature	4.2	6.4	1.2	33.3	40.9	48.2	49.4	49.2	39.9	24.9	11.0	4.1
1933												
Minimum	−19	−30	−23	+14	+31	+32	+39	+35	+26	+5	+3	−40
Date of occurrence	4	11	2	8	10	22	20	25	27	22	4	27
Average daily maximum temperature	14.1	17.6	29.6	47.2	62.1	69.5	72.7	75.5	59.1	45.7	38.3	−3.9
Average daily minimum temperature	5.0	4.7	6.4	27.6	39.1	45.0	47.7	47.8	37.4	23.8	23.0	−16.4
1934												
Minimum	−26	−23	−5	+19	+28	+33	+37	+25	*			
Date of occurrence	24	24	9	15	12	2	5	24				
Average daily maximum temperature	28.4	32.5	35.8	57.1	67.6	66.6	72.4	71.1				
Average daily minimum temperature	4.8	10.1	16.2	33.3	40.7	44.6	46.6	44.4				

*The investigation was concluded at the end of September, 1934.

TABLE 4.—FREQUENCY AVERAGES OF PLANTS OF SPECIES PER SQUARE FOOT AND PERCENTAGES AS DETERMINED BY COUNTS OF THE NUMBER OF PLANTS IN 12 SYSTEMATICALLY DISTRIBUTED SAMPLE STRIPS

Pasture A

Year	Season of counting		Brome grass	Crested wheat grass	Slender wheat grass	Kentucky blue grass	Alfalfa	Sweet clover	Alsike clover	Total	Annual weeds	Perennial weeds
1931	Autumn	F*	5.2±1.0	4.6±0.7	3.8±0.9	4.7±0.7	10.4±0.9	5.8±0.4	6.3±0.8	40.8	0.6	—
		%	12.7	11.3	9.2	11.5	25.5	14.2	15.4	100		
1932	Spring	F	9.0±1.1	6.0±1.4	6.8±0.8	8.9±1.5	6.9±0.7	6.0±0.6	2.4±0.4	46.0	—	0.1
		%	19.9	13.0	14.7	19.3	15.0	13.0	5.2	100		
	Summer	F	9.3±1.5	4.3±0.7	5.9±1.0	9.7±1.1	9.0±0.8	5.3±0.8	10.3±1.2	53.8	0.8	0.2
		%	17.2	7.9	11.0	18.0	16.8	9.9	19.1	100		
	Autumn	F	7.9±1.0	2.0±0.3	3.9±0.5	13.0±1.4	8.3±0.8	3.3±0.5	6.6±0.8	45.0	—	0.3
		%	17.6	4.4	8.7	28.9	18.4	7.3	14.7	100		
	Check	F	14.8±0.7	3.7±0.6	3.8±0.7	11.3±1.5	8.7±0.8	1.0±0.5	7.7±1.2	51.0	0.1	0.4
	Autumn (unpastured)	%	29.0	7.3	7.5	22.2	17.1	2.0	15.1	100		
1933	Spring	F	9.1±1.2	2.2±0.5	1.9±0.1	12.3±1.7	6.0±0.4	—	3.9±0.8	35.4	—	—
		%	25.7	6.2	5.4	34.7	17.0	—	11.1	100		
	Check	F	13.8±1.1	2.5±0.4	2.9±0.5	11.9±0.7	7.0±0.5	—	2.6±0.7	40.7	—	0.3
	Spring (unpastured)	%	33.9	6.1	7.2	29.3	17.2	—	6.3	100		
	Autumn	F	8.9±0.9	1.0±0.2	1.6±0.4	15.9±1.3	6.6±0.7	†0.2±0.1	5.0±1.3	39.2	0.1	0.2
		%	22.7	2.6	4.1	40.6	16.8	0.5	12.8	100		
	Check	F	12.7±0.9	1.7±0.3	1.5±0.3	13.9±0.9	7.8±0.5	—	3.6±1.0	41.2	0.1	0.5
	Autumn (unpastured)	%	30.9	4.1	3.7	33.8	18.9	—	8.7	100		

TABLE 4.—FREQUENCY AVERAGES OF PLANTS OF SPECIES PER SQUARE FOOT AND PERCENTAGES AS DETERMINED BY COUNTS OF THE NUMBERS OF PLANTS IN 12 SYSTEMATICALLY DISTRIBUTED SAMPLE STRIPS—*Concluded*

Pasture A

Year	Season of counting		Brome grass	Crested wheat grass	Slender wheat grass	Kentucky blue grass	Alfalfa	Sweet clover	Alsike clover	Total	Annual weeds	Perennial weeds
1934	Spring	F	10.8±1.6	1.6±0.5	2.0±0.4	25.8±0.9	5.9±0.8	†0.5±0.2	4.5±1.6	51.1	0.1	0.1
		%	21.1	3.1	3.9	50.5	11.5	1.0	8.8	100		
	Check	F	12.4±1.0	0.9±0.4	1.2±0.4	21.9±1.1	7.1±0.5	†0.2±0.1	3.4±1.1	47.1	—	0.2
	Spring (unpastured)	%	26.3	1.9	2.5	46.5	15.0	0.4	7.2	100		
	Autumn	F	7.1±0.1	0.3±0.2	1.2±0.3	28.0±1.1	6.4±0.7	—	—	43.0	—	0.1
		%	16.5	0.7	2.8	65.1	14.9	—	—	100		
	Check	F	10.5±0.9	—	0.7±0.3	24.4±0.9	6.3±0.4	—	2.6±0.2	44.5	—	0.2
	Autumn (unpastured)	%	23.6	—	1.6	54.8	14.2	—	5.8	100		

NOTE—Standard errors of the means are given.
*F = frequency averages.
†Seedlings.
Dates of counts: 1931—November 3 and 4.
1932—April 30, June 6 and 7, August 20.
1933—May 13 (pasture), 24 (unpastured check), August 26 (pasture and unpastured check).
1934—May 19, September 14.

TABLE 5.—FREQUENCY AVERAGES OF PLANTS OF VARIOUS SPECIES PER SQUARE FOOT AND PERCENTAGES AS DETERMINED BY COUNTS OF THE NUMBER OF PLANTS IN 12 SYSTEMATICALLY DISTRIBUTED SAMPLE STRIPS

Pasture B

Year	Season of counting		Slender wheat grass	Timothy	Kentucky blue grass (not seeded)	Altaswede red clover	Alsike clover	Total	Annual weeds	Perennial weeds
1932	Spring	F*	5.5±1.1	28.1±2.1	—	11.3±1.1	15.4±1.6	60.3	—	—
		%	9.1	46.7	—	18.7	25.5	100		
	Summer	F	7.2±0.7	22.7±1.5	0.6±0.3	10.3±0.9	14.1±1.6	54.9	—	—
		%	13.1	41.4	1.0	18.9	26.0	100		
	Autumn	F	4.3±0.7	16.3±1.1	0.4±0.3	8.3±1.0	9.5±0.9	38.8	0.2	—
		%	11.1	42.0	1.0	21.4	24.5	100		
	Check (Unpastured)	F	8.5±1.1	22.6±1.1	0.1±0.1	9.0±0.9	13.9±1.1	54.1	0.1	0.5
		%	15.7	41.8	0.2	16.6	25.7	100		
1933	Spring	F	3.5±0.6	16.0±0.7	1.4±0.7	5.2±0.9	4.0±1.0	30.1	—	0.1
		%	11.6	53.1	4.7	17.3	13.3	100		
	Check (Unpastured)	F	6.5±0.9	14.9±1.1	0.3±0.2	5.4±0.6	6.7±0.9	33.8	—	0.3
		%	19.2	44.1	0.9	16.0	19.8	100		
	Autumn	F	1.9±0.4	15.5±0.7	1.8±0.5	4.8±0.8	4.9±0.8	28.9	0.2	0.1
		%	6.6	53.6	6.2	16.6	17.0	100		
	Check (Unpastured)	F	5.0±0.8	16.7±1.0	1.1±0.4	4.8±0.6	7.1±1.0	34.7	0.4	0.3
		%	14.4	48.1	3.2	13.8	20.5	100		
1934	Spring	F	2.7±0.4	15.6±1.8	5.6±1.1	0.9±0.6	0.7±0.5	25.5	0.3	—
		%	10.6	61.2	22.0	3.5	2.7	100		
	Check (Unpastured)	F	4.7±0.6	16.9±0.7	1.9±0.5	1.8±0.5	2.1±0.8	27.4	—	0.1
		%	17.2	61.7	6.9	6.6	7.7	100		
	Autumn	F	1.9±0.2	16.1±1.6	6.3±1.0	3.1±0.9	7.2±2.3	34.6	0.3	0.1
		%	5.5	46.5	18.2	9.0	20.8	100		

*F = frequency averages.
No counts were made on this pasture in 1931 as the plants were too dry at time of counting to make identification possible.
Dates of counts: 1932—April 3, June 4, August 13.
1933—May 14 (pasture), 24 (unpastured check), August 28 (pasture and unpastured check).
1934—May 7, September 8 (pasture only).

TABLE 6.—FREQUENCY AVERAGES OF PLANTS OF VARIOUS SPECIES PER SQUARE FOOT AND PERCENTAGES AS DETERMINED BY COUNTS OF THE NUMBER OF PLANTS IN 12 SYSTEMATICALLY DISTRIBUTED SAMPLE STRIPS

Pasture C

Year	Season of counting		Brome grass	Kentucky blue grass	Alfalfa	Dutch clover	Total	Annual weeds	Perennial weeds
1931	Autumn	F*	8.0±1.6	20.9±1.5	4.8±1.1	16.1±1.5	49.8	2.4	1.2
		%	16.1	42.0	9.7	32.3	100		
1932	Spring	F	9.9±2.7	28.6±1.9	8.8±1.2	15.6±1.7	62.9	†	†
		%	15.7	45.5	13.9	24.9	100		
	Summer	F	9.1±1.6	25.1±2.2	7.7±0.9	16.1±1.1	58.0	0.5	0.6
		%	15.7	43.3	13.2	27.8	100		
	Autumn	F	10.7±1.2	22.3±1.7	6.9±0.7	8.4±0.7	48.3	0.1	1.1
		%	22.1	46.1	14.3	17.5	100		
1933	Spring	F	11.2±1.6	20.8±1.7	5.3±0.9	1.1±0.5	38.4	1.1	0.3
		%	29.2	54.2	13.9	2.8	100		
	Autumn	F	10.1±1.1	21.9±1.8	4.3±0.6	1.1±0.5	37.4	0.1	0.3
		%	26.9	58.6	11.6	2.9	100		
1934	Spring	F	13.3±1.8	26.8±1.2	3.6±0.7	none	43.7	0.1	none
		%	30.4	61.3	8.2		100		
	Autumn	F	9.8±0.9	26.3±1.3	3.6±0.5	none	39.7	none	none
		%	24.7	66.2	9.1		100		

No enclosures were placed in this pasture.
*F = frequency averages.
†Weeds were too minute for identification.
Date of counts: 1931—October 26.
1932—April 30, June 9, August 18.
1933—May 14, September 2.
1934—May 12, September 8.

TABLE 7.—FREQUENCY AVERAGES OF PLANTS OF VARIOUS SPECIES PER SQUARE FOOT AND PERCENTAGES AS DETERMINED BY COUNTS OF THE NUMBER OF PLANTS IN 12 SYSTEMATICALLY DISTRIBUTED SAMPLE STRIPS

Pasture D

Year	Season of counting		Crested wheat grass	Brome grass	Kentucky blue grass	Dutch clover	Sweet clover	Total	Annual weeds	Perennial weeds
1931	Autumn	F*	6.8±1.2	4.1±1.0	18.3±2.2	11.8±1.1	8.8±0.9	49.8	0.6	0.1
		%	13.7	8.2	36.7	23.6	17.8	100		
1932	Spring	F	2.6±0.6	6.8±1.5	20.1±1.5	15.1±1.6	6.4±1.0	51.0	—	—
		%	5.2	13.2	39.5	29.7	12.5	100		
	Summer	F	4.3±0.7	6.9±1.5	25.1±2.7	20.3±1.0	4.6±0.6	61.2	0.3	0.4
		%	7.1	11.3	41.0	33.1	7.5	100		
	Autumn	F	4.1±0.8	8.8±1.4	25.5±1.9	11.9±1.2	3.2±0.6	53.5	0.3	0.3
		%	7.6	16.5	47.7	22.3	5.9	100		
	Check	F	5.0±0.7	11.3±0.9	25.1±2.6	15.1±0.9	2.4±0.5	58.9	—	0.1
	Autumn (Unpastured)	%	8.5	19.2	42.6	25.6	4.1	100		
1933	Spring	F	3.3±0.5	8.3±1.2	25.6±1.3	0.9±0.4	—	38.1	0.3	0.1
		%	8.6	21.7	67.3	2.4	—	100		
	Check (Unpastured)	F	3.0±0.6	11.5±0.9	20.3±1.3	1.7±0.4	—	36.5	0.1	—
		%	8.2	31.5	55.7	4.6	—	100		
	Autumn	F	1.8±0.4	9.4±1.0	22.8±0.9	3.7±0.7	—	37.7	0.4	0.1
		%	4.7	25.0	60.6	9.7	—	100		
	Check (Unpastured)	F	1.5±0.1	13.0±1.3	21.8±1.6	3.6±1.3	1.0±0.5†	40.9	0.3	—
		%	3.7	31.8	53.3	8.8	2.4	100		
1934	Spring	F	2.3±0.4	10.0±0.9	26.7±1.2	0.5±0.2	0.6±0.4†	40.1	0.1	—
		%	5.7	24.9	66.6	1.2	1.5	100		
	Check (Unpastured)	F	1.0±0.3	13.0±1.0	30.6±1.2	2.3±0.9	0.3±0.1†	47.2	1.8	—
		%	2.1	27.5	64.8	4.9	0.6	100		
	Autumn	F	0.5±0.2	8.8±0.9	29.0±0.9	1.5±0.5	—	39.8	0.3	—
		%	1.3	22.1	72.9	3.8	—	100		
	Check Unpastured)	F	0.6±0.3	10.8±0.8	28.0±1.2	5.3±1.9	0.5±0.2†	45.2	0.2	—
		%	1.3	23.9	61.9	11.7	1.1	100		

*F = frequency averages.
†These plants were seedlings. A few plants of Dutch clover were also seedlings.

Dates of counts: 1931—October 27 and 29.
1932—April 20, June 11, August 24 (pasture), 23 (unpastured check).
1933—May 19, 20 (pasture), 27 (unpastured check), August 28 (pasture), August 26 (unpastured check).
1934—May 12 (pasture), 19 (unpastured check).

TABLE 8.—FREQUENCY AVERAGES OF PLANTS OF VARIOUS SPECIES PER SQUARE FOOT AND PERCENTAGES AS DETERMINED BY COUNTS OF THE NUMBER OF PLANTS IN 12 SYSTEMATICALLY DISTRIBUTED SAMPLE STRIPS

Pasture E

Year	Season of counting		Crested wheat grass	Kentucky blue grass	Alfalfa	Dutch clover	Total	Annual weeds	Perennial weeds
1931	Autumn	F*	5.3±0.8	13.3±2.2	6.8±0.7	13.9±1.1	39.3±2.8	0.3	0.2
		%	13.5	33.8	17.3	35.4	100.0		
1932	Spring	F	4.4±0.7	19.1±3.2	4.9±0.5	13.1±1.3	41.5±3.9	—	—
		%	10.6	46.0	11.8	31.6	100.0		
	Summer	F	5.2±0.8	25.4±2.7	5.6±0.7	14.1±0.9	50.3±2.7	0.3	0.3
		%	10.3	50.5	11.1	28.0	99.9		
	Autumn	F	3.9±0.5	20.8±1.5	4.4±0.6	8.8±0.6	37.9±1.3	—	0.9
		%	10.3	54.9	11.6	23.2	100.0		
	Check (Unpastured)	F	5.8±0.9	23.9±1.9	5.7±0.6	8.3±1.0	43.7±2.4	—	0.1
		%	13.3	54.7	13.0	19.0	100.0		
1933	Spring	F	3.6±0.5	25.5±2.7	4.0±0.5	0.5±0.2	33.6±2.6	—	0.3
		%	10.7	75.9	11.9	1.5	100.0		
	Check (Unpastured)	F	6.3±0.7	21.0±1.1	5.3±0.7	0.3±0.1	32.9±1.3	0.3	0.1
		%	19.1	63.8	16.1	0.9	99.9		
	Autumn	F	3.1±0.4	22.6±1.0	3.8±0.8	1.0±0.5	30.5±1.3	0.3	0.2
		%	10.2	74.1	12.5	3.3	100.1		
	Check (Unpastured)	F	6.1±1.0	21.9±0.9	5.0±0.6	0.7±0.4	33.7±1.0	0.2	—
		%	18.1	65.0	14.8	2.1	100.0		
1934	Spring	F	2.8±0.4	38.0±0.9	0.1±0.0	—	40.9±0.7	2.5	—
		%	6.8	92.9	0.2	—	99.9		
	Check (Unpastured)	F	4.0±0.7	35.1±0.9	4.5±0.4	—	43.6±0.7	—	0.1
		%	9.2	80.5	10.3	—	100.0		
	Autumn	F	2.2±0.5	30.5±1.1	1.0±0.4	0.7±0.4	34.4±1.1	—	—
		%	6.4	88.7	2.9	2.0	100.0		
	Check (Unpastured)	F	4.1±1.1	35.4±1.1	5.4±0.5	—	44.9±1.2	—	—
		%	9.1	78.8	12.0	—	99.9		

*F = frequency averages.
Dates of counts: 1931—November 4.
1932—April 29, May 28, August 14.
1933—May 14 (pasture), 24 (unpastured check), August 29 (pasture and unpastured check).
1934—May 7 (pasture and unpastured check).

The weed species have been grouped into annuals and perennials in the tables, as the frequency of any one species was very low and therefore not significant in comparison with the counts of the plants of the seeded species. For the convenience of the reader the common and botanical names of the weeds grouped in Tables 4 to 9 are given as follows: annuals: hemp nettle, *Galeopsis Tetrahit* L.; lamb's quarters, *Chenopodium album* L.; knotweed, *Polygonum neglectum* Besser; stinkweed, *Thlaspi arvense* L.; Russian pigweed, *Axyris amarantoides* L.; cinquefoil, *Potentilla monspeliensis* L.; perennials: plantain, *Plantago major* L.; Canada thistle, *Cirsium arvense* (L.) Scop.; dandelion, *Taraxacum officinale* (Weber).

The results of plant counts supplemented by critical notes indicate quite definitely some of the limitations and some of the virtues of the six pasture mixtures studied. Since the quality of a pasture mixture is no better than the combined qualities of its constituent species, it would seem appropriate to discuss these species individually before making comments on the mixtures themselves.

Table 9.—Frequency averages of plants of various species per square foot and percentages as determined by counts of the number of plants in 12 systematically distributed sample strips

Pasture F

Year	Season of counting		Brome grass	Alfalfa	Total	Annual weeds	Perennial weeds
1931	Autumn	F*	8.2±0.9	14.1±1.6	22.3	1.2	1.2
		%	36.8	63.2	100		
1932	Spring	F	9.4±1.1	12.3±1.0	21.7	†	†
		%	43.3	56.7	100		

*F = frequency averages.
†Weeds were not counted in this pasture in 1932 as they were too small for identification.
Dates of counts: 1931—November 4, 1932—April 29.

From an examination of Tables 4 to 9 it will readily be seen that the more important species from the standpoint of maintaining the constancy of a pasture stand are brome grass and Kentucky blue grass. Alfalfa remained almost constant, except in Pasture E, in which it had disappeared almost entirely in the grazed area in 1934. All the other species, according to the data, were in a state of decline after the expiration of the second season, with complete killing out of sweet clover and later of the Dutch clover. Sweet clover being biennial would be expected to disappear at the end of the second year, but Dutch clover, being perennial, might be expected to survive for several years. The disappearance of the latter must be accounted for in some other way.

The killing out of Dutch clover in 1932 and 1933 was probably due to four main factors: (1) interspecific competition, involving shading by taller species; (2) the nature of the plant itself; (3) droughty conditions the previous fall (1932); and (4) extremely low temperatures during the winter months, combined with an inadequate snow covering. The data (Tables 6, 7 and 8) show that the decline of this species began in the late summer of 1932 and continued with almost complete killing out in the spring of 1933. This decrease was about equal in Pastures C, D and F, which contained

Dutch clover in the mixtures. Pasture C had produced very rank growths of brome grass and alfalfa, pasture E of brome and sweet clover, and pasture F of crested wheat grass and alfalfa in 1932 (Tables 15, 17, 18 and 19). Pastures C and D, it will be recalled, were not grazed in June 1932, but were cut for hay in the second week in July. Moreover, these pastures were grazed very closely until fall, after the hay crop had been removed, D by sheep and C by young bulls. Accordingly it would seem probable that the combined effects of shading and crowding by the tall-growing species followed by severe grazing the second season contributed largely to the killing of Dutch clover. Also drought and hot weather in August and September of 1932 combined with the crowding and shading effects of the taller-growing associated species may have so weakened the Dutch clover plants that they could not withstand the severity of the following winter. However, no definite proof can be given to support the view that winter temperature was the final cause of killing of this plant. Furthermore, the results (Tables 6, 7 and 8) seem to suggest that Dutch clover might only be a relatively short-lived perennial. This view finds support in the work of Roberts and Jones (*8*) in Wales, and of Fenton (*4*), in England who found Dutch clover of value in pasture mixtures in the first year of grazing only, as in subsequent years it rapidly disappeared. Accordingly, from the results obtained and the supporting evidence found in the literature the conclusion would seem justified, that Dutch clover, as a constituent of pasture mixtures under the conditions of the investigation is very short-lived and of little value over a period of more than two years.

Two other species which also proved to be very undesirable from the point of view of persistence (Tables 4, 5 and 8) are crested wheat and slender wheat grasses. Both of these species had gone out almost entirely in pastures A, B and D by the autumn of 1934; crested wheat grass seemed to have decreased less in pasture E, however, for some unaccountable reason. No work with these grasses is reported in the literature reviewed.

A very noticeable feature of pasture B was the reduction of alsike and Altaswede clovers, the former from $25 \cdot 5$ to $2 \cdot 7\%$ and the latter from $18 \cdot 7$ to $3 \cdot 5\%$ by the spring of 1934. Alsike by the end of 1932 was found localized in low lying areas in pastures A and B, where, owing to greater moisture, this plant grew better than Altaswede red clover. The decline of alsike is also reported by European workers, notably Fenton (*3*) and Stapledon and Davies (*11*); and by Hein and Vinall (*7*), working in the United States. It was only in districts where moisture was more abundant that this plant competed successfully in mixtures with red clover. For these reasons the undesirability of alsike clover in pasture mixtures, except on moist land, will be readily recognized. Altaswede red clover did not prove altogether satisfactory for permanent pasture purposes either, because of its susceptibility to winter injury and its relatively short-life (although perennial) habit.

Alfalfa showed remarkable persistence in all the pastures in which it was seeded throughout the duration of the investigation, except in pasture E, in which it decreased in the grazed area from $12 \cdot 5\%$ in the fall of 1933 to $0 \cdot 2\%$ in the spring of 1934. This sharp decrease was not nearly so marked in the unpastured check. No explanation can be given at present for this rapid deterioration of alfalfa in pasture E over the winter 1933–34, as compared with its survival in other pastures.

Timothy gave evidence of being a very persistent species, as its frequency remained almost constant, except for a slight decrease in 1933. Fenton (*3*) reports that timothy was not a success in pasture mixtures in England, it being eventually crowded out and replaced by species of *Lolium* and *Agrostis*, and by *Dactylis glomerata*. This replacement would scarcely be expected to occur in the Edmonton district owing to the semi-arid climate under which these latter species would likely be less strongly competitive.

The persistence of brome and Kentucky blue grasses is clearly brought out by the data. The point of importance here is the fact that they appear to form an association without causing any marked injury one to the other. However, Kentucky blue grass appears to be somewhat the more aggressive species, and it would be interesting to study these two grasses in association over a much longer period of time than that covered by our investigation. Kentucky blue grass, while less desirable from the standpoint of yield, as will be shown later, is an excellent turf-forming species, a fact which appears to render it a strong competitor with weeds. This is amply supported in the literature.

The counts of weeds reveal no significant changes. The number of counts would need to be greatly increased before definite changes could be fully established. Critical notes reveal, however, that weeds were kept well in check by the turf-forming brome and Kentucky blue grasses.

Yields of Herbage

The data on yields per acre were secured for pastures A, B, D and E, but not for pasture F.

The yields of green herbage were computed from the weights of green material cut at intervals from the six-feet-square areas in each of the three fenced enclosures of each pasture. The yields per acre of air-dried fodder were calculated from data on the green weights and the final weights of air-dried composite samples of herbage. It is true that these results do not properly represent the productivity of the actual pastured areas, since the enclosed areas were not subjected to actual pasturing conditions such as trampling, dropping of manure and selective defoliation. Clippings of these enclosed areas at much more frequent intervals would have given results more appropriate for the estimations of pasture yields, but the more frequent clippings were impracticable under the circumstances. Although the data obtained are not strictly applicable to the pastured areas, the authors believe that they do provide some means of comparing, in a crude way, the various mixtures with respect to their productivity.

The yield data are presented in the first four columns of Tables 10 to 13. The proportions of legumes, grasses and weeds were determined from the cut herbage by a method described earlier in this paper. The data for these proportions are given in the last three columns of the same tables.

The yields secured from the various pastures in all three harvest years were very gratifying, except those from pasture D, in both 1933 and 1934, as indicated in Tables 12 and 14. The total yields of dry herbage (Table 14) the first harvest year were, on the average, a third greater than those in the second year. This might be expected, especially from pastures A and

TABLE 10.—YIELDS PER ACRE OF GREEN AND DRY HERBAGE, ALSO PERCENTAGES OF LEGUMES, GRASSES AND WEEDS

Pasture A

Year	Cutting dates	Green weight in pounds per acre	Dry weight in pounds per acre	Percentages		
				Legumes	Grasses	Weeds
1932	July 11	27,000	8,200	46	54	None
	Aug. 30	4,600	1,800	35	65	None
	Total	31,600	10,000	Av. 40.5	59.5	
1933	June 5	8,200	2,500	22	78	Trace
	July 13	8,100	2,000	52	48	Trace
	Aug. 29	5,600	1,600	80	20	Trace
	Total	21,900	6,100	Av. 51.3	48.7	Trace
1934	June 8	7,300	2,200	38	62	None
	July 24	5,900	1,500	69	31	Trace
	Sept. 8	2,800	900	84	16	None
	Total	16.000	4,600	Av. 63.7	36.3	Trace

TABLE 11.—YIELDS PER ACRE OF GREEN AND DRY HERBAGE, ALSO PERCENTAGES OF LEGUMES, GRASSES AND WEEDS

Pasture B

Year	Cutting dates	Green weight in pounds per acre	Dry weight in pounds per acre	Percentages		
				Legumes	Grasses	Weeds
1932	July 5	20,200	6,000	37	64	Trace
	Aug. 27	4,700	2,000	30	70	Trace
	Total	24,900	8,000	Ave.33.5	67.0	Trace
1933	June 6	9,200	2,500	4	96	Trace
	July 15	6,200	2,100	31	69	Trace
	Sept. 1	2,400	800	22	78	Trace
	Total	17,800	5,400	Ave.19.0	81.0	Trace

Yield determinations were not made on this pasture in 1934.

TABLE 12.—YIELDS PER ACRE OF GREEN AND DRY HERBAGE, ALSO PERCENTAGES OF LEGUMES, GRASSES AND WEEDS

Pasture D

Year	Cutting dates	Green weight in pounds per acre	Dry weight in pounds per acre	Percentages		
				Legumes	Grasses	Weeds
1932	July 7	27,500	7,500	49	51	None
	Aug. 29	6,500	2,700	32	68	None
	Total	34,000	10,200	Av. 40.5	59.5	
1933	June 6	7,500	2,300	Trace	98	2
	July 14	3,900	1,300	3	94	2
	Aug. 30	1,400	500	1	98	1
	Total	12,800	4,100	Av. 1.3	96.7	1.7
1934	June 9	4,000	1,500	2	97	2
	July 28	2,100	900	Trace	100	–
	Total	6,100	2,400	Av– 1.0	98.5	1.0

TABLE 13.—YIELDS PER ACRE OF GREEN AND DRY HERBAGE, ALSO PERCENTAGES OF LEGUMES, GRASSES AND WEEDS

Pasture E

Year	Cutting dates	Green weight in pounds per acre	Dry weight in pounds per acre	Percentages		
				Legumes	Grasses	Weeds
1932	July 9	24,200	7,600	41	55	4
	Aug. 31	5,000	2,000	54	46	Trace
	Total	29,200	9,600	Av. 47.5	50.5	2.0
1933	June 9	10,700	3,000	33	68	None
	July 16	7,900	2,600	57	43	None
	Sept. 4	4,300	1,500	66	34	None
	Total	22,900	7,100	Av. 52.0	48.3	None
1934	June 4	7,200	2,200	32	68	None
	July 26	6,700	2,000	57	43	None
	Sept. 9	2,700	900	79	21	None
	Total	16,600	5,100	Av. 56·0	44·0	None

TABLE 14.—SUMMARY OF TOTAL YIELDS PER ACRE OF GREEN AND DRY HERBAGE FROM PASTURES A, B, D, AND E FOR 1932, 1933 AND 1934

		A	*B*	*D*	*E*
Species and pounds of seed per acre used in the mixtures		Brome grass .... 2.8 Crested wheat grass... 2.5 Slender wheat grass... 0.7 Kentucky blue grass.. 3.0 Alfalfa.............. 3.0 Sweet clover......... 3.0 Alsike clover......... 2.0	Slender wheat grass... 5.0 Timothy............. 3.0 Altaswede red clover.. 4.0 Alsike clover......... 3.0	Crested wheat grass... 2.0 Brome grass.......... 2.7 Kentucky blue grass.. 4.0 White Dutch clover... 5.0 Sweet clover......... 3.0	Crested wheat grass.... 5.0 Kentucky blue grass... 4.0 Alfalfa................ 3.0 White Dutch clover.... 2.0
Year	State of herbage	Pounds of herbage	Pounds of herbage	Pounds of herbage	Pounds of herbage
1932	green dry	31,600 10,000	24,900 8,000	34,000 10,200	29,200 9,600
1933	green dry	21,900 6,100	17,800 5,400	12,800 4,100	22,900 7,400
1934	green dry	16,000 4,600	Not taken Not taken	6,100 2,400	16,600 5,100

D in view of the crowding out of Dutch clover on the one hand, and the complete elimination of the bulky sweet clover on the other. Similarly, a further decrease in yield occurred in 1934. This decrease in 1934 was particularly marked in pasture D. The decrease in yields from the first to the second year was less marked in pastures B and E, the reason being that the former pasture contained clovers which had decreased but little, while the latter contained alfalfa which yielded even more abundantly in the second than in the first year. The pastures may be arranged in descending order of yield for the different years as follows:

1932—D, A, E, B
1933—E, A, B, D
1934—E, A, D.

It will be observed that pasture D changed from highest place in 1932 to lowest place in 1933, which place it also held in 1934. This is a particularly interesting result when compared with the results from pasture A in 1933, which also originally contained sweet clover. The comparatively higher yield from the latter in 1933 must be attributed mainly to alfalfa. It will also be noted that pasture E, which took third place in 1932, rose to first place in 1933 and remained there in 1934. This change may be accounted for on the basis of the more rapid growth of alfalfa and Kentucky blue grass. Moreover, it will also be seen that the position of pasture A remains unchanged in the order of yield from the first to the second harvest year in spite of the dying out of sweet clover. This is also attributable largely to increased growth of the alfalfa and partly to the increased proportions of Kentucky blue and brome grasses in the pasture. Pasture B changed from lowest to third place from 1932 to 1933. This may be accounted for partly by the excellent growth made by the timothy in the drier months, even though the clovers added little to the bulk of the herbage at that time of the season. This change is also partly due to the marked decline of pasture D in yield from 1932 to 1933. Pasture E varied least in yield from cutting to cutting, and from the first to the second harvest year. The decrease in its yield was only about 25%, on the average, as against 40 in A, 56 in B, and 60% in D. This indicates quite definitely that pasture E, from the standpoint of productivity alone, is more desirable than any of the other three pastures. Pasture D, on the other hand, is shown to be the most disappointing mixture of the whole group; for this reason its suitability, after the first and second crop years for Edmonton conditions, would seem to be questionable, although its yield in the first year was very high on account of the sweet clover.

If the cut herbage be regarded as hay, the corresponding yields of actual pasture would be expected to be considerably less. Wolfe (*13*) found that the cut herbage available as pasturage was from 40 to 65% of the yield of hay. Shutt, Hamilton and Selwyn (*9*), Fenton (*3*), and others, have found that yield of pastures decreases with the frequency of cutting off the herbage. The pastures herein considered were cut twice in 1932, and three times annually thereafter, except for Pasture B which was not cut at all in 1934. The frequencies of cutting in this investigation may therefore be regarded as intermediate between cutting for hay, as ordinarily practised, and cutting at short intervals to approximate conditions of actual pasture defoliation. Our yield results may be regarded

as probably greater than the true yields of pasturage and somewhat less than the yields likely to have been realized if the crops had been cut for hay. However this may be, it would seem that the yields from the various pastures may be legitimately considered comparatively as has been done above.

Changes in the Proportions of Legumes, Grasses and Weeds

Certain seasonal changes occurred in the percentages of legumes and grasses in the pasture herbage, as indicated in Tables 10 to 13.

The leguminous content of the herbage in the first cutting in 1932 was only slightly below the percentages of grasses, and was composed chiefly of sweet clover in pastures A and D, alfalfa in pasture E, and of about equal quantities of red and alsike clovers in pasture B. The second cutting in the same year revealed an increase in grasses, with a corresponding decrease in the leguminous content, except in pasture E, where leguminous herbage was in excess. This time alfalfa was the predominant legume in pasture A, and sweet clover in D. Dutch clover was present only in small quantities in D, while the grass content was chiefly brome in both. The legume content of B was two-thirds Altaswede red clover and one-third alsike clover, and the grasses were mainly timothy. The leguminous material from pasture E consisted chiefly of alfalfa, and the grass portion of about equal parts of crested wheat and Kentucky blue grasses.

The 1933 data point to somewhat different results. The legume content was quite low in the spring, but increased rapidly, until in the third cutting it greatly exceeded the grass portion, except in pastures B and D. In pasture B a marked increase in legume content was shown in the second cutting, but a decrease had again occurred by the third cutting. A similar trend was evident in pasture D, but here the proportions of legumes were very small. In pasture B the percentage of legumes was 4 and consisted of about equal parts of Altaswede red clover and alsike clover; the grass content was about 80% timothy and 20% slender wheat grass. Pasture D consisted of a trace only of legumes (entirely Dutch clover), 2% weeds and 97% grasses; the grass portion was composed, on the average, of 70% brome grass, 25% Kentucky blue grass and 5% slender wheat grass. Pasture E gave 33% legumes and 67% grasses in the first cutting; the former consisted of alfalfa with a trace of Dutch clover, and the latter was made up of 65% Kentucky blue grass with the remainder crested wheat grass.

In the herbage of the second cutting for 1933, the leguminous portions were seen to be increasing and the gramineous portions decreasing. This increase in leguminous content continued in the herbage of the third cutting, except in pastures B and D, as previously mentioned. In the second cutting of pasture A the 52% legumes was composed of 80% alfalfa and 20% alsike, and the 48% grass was mainly brome grass. In pasture B the 31% legumes consisted of two to three times as much Altaswede red clover as alsike, and the 69% grasses was about 90% timothy and 10% slender wheat grass. Pasture D yielded mainly grasses (94%) consisting of 65% brome, 25% slender wheat, and about 10% crested wheat grasses; and 2% weeds. In pasture E the 57% legume consisted entirely of alfalfa, and the 43% grasses contained 70% Kentucky blue grass and 30% crested wheat grass.

Certain interesting changes also occurred in the herbage between the second and third cuttings in 1933. In pasture A alfalfa had increased to about 97% of the leguminous content with a corresponding decrease in alsike to 3%; the grass portion consisted of 90% brome grass, 2% crested wheat grass and 8% Kentucky blue grass. In pasture B the leguminous content, which consisted of 75% Altaswede and 25% alsike clovers, showed a decrease with a corresponding increase in the gramineous herbage, which was composed of 97% timothy and 3% slender wheat grass. In pasture D the leguminous herbage, which was Dutch clover only in 1933, had decreased to 1%; the grass portion which had increased to 98% consisted of 75% brome grass, 23% Kentucky blue grass, and 2% crested wheat grass. The weed content was 1%, which indicates some decrease from the second cutting. In pasture E the increase in the proportion of legumes was somewhat less than in pasture A. This difference is due to alsike clover in the latter, whereas the former pasture contained alfalfa as the sole legume. The gramineous portion of pasture E consisted of about 85% Kentucky blue grass and 15% crested wheat grass.

In 1934 three cuttings were taken from the enclosures in pastures A and E; two cuttings were taken from pasture D, but no cuttings were obtained from pasture B. The changes in the grass-legume proportions were very similar to those noted in 1933 for the same pastures. It is to be noted, however, that the proportions of legumes in pastures A and E average higher, while the percentages of grasses are correspondingly lower, in 1934 than in either of the preceding years. This is particularly noticeable for the third cuttings in the seasons. In pasture D the herbage cut was almost entirely grass. The legume portion of pasture A for 1934 was almost wholly alfalfa with a trace of alsike; the grass portion contained about equal amounts of brome and Kentucky blue grass, with traces of crested wheat and slender wheat grasses. The legume portion of pasture E was also entirely alfalfa, except for a trace of Dutch clover; while the grass portion averaged about 73% Kentucky blue grass and about 27% crested wheat grass. For pasture D the legume portion was a trace of sweet clover, while the grass portion contained about 65% brome grass and about 35% Kentucky blue grass with traces of crested wheat and slender wheat grasses.

The comparative predominance of alfalfa, brome and Kentucky blue grasses and timothy in these pastures is particularly evident, while Dutch clover, alsike and Altaswede red clover, slender wheat and crested wheat grasses tended to become relatively less abundant from year to year, and also from spring to autumn in the different years.

The factors thought to be most effective in bringing about these changes are drought, temperature extremes, biological and mechanical factors, and the natural life periods of the plants themselves. While the changes in legume-grass proportions were undoubtedly due in large measure to the interaction of these factors, it would seem appropriate to consider them in brief separately.

The survival and prominence of alfalfa would seem to have resulted from the deeply rooted nature of the plant, thus enabling it during dry periods of the year to draw upon moisture supplies at lower depths, which were not available to the more shallow-rooted Altaswede red clover, alsike and Dutch clovers. Altaswede red clover appeared to be more drought-resistant than alsike, as might be expected, the latter being particularly

adapted to moist soil conditions. The decreases in herbage from slender wheat and crested wheat grasses were no doubt attributable to plant competition to a greater extent than to drought, since both are fairly drought-resistant. Brome grass being quite drought-resistant made fairly good growth, even in the drier months. Kentucky blue grass, though not as drought-resistant as some other grasses, appeared to have good regenerative power, as it made rapid growth after each rain. The alfalfa, brome grass and Kentucky blue grass appeared to thrive in company with one another and may possibly be regarded as forming a successful association in an ecological sense. A longer period of time would, however, be required to test the stability of this association.

Extremely low temperatures, especially in early spring, appeared to be injurious to all the clovers and alfalfa. Dutch and alsike clovers suffered the greatest injury at this time, while Altaswede red clover, sweet clover and alfalfa sustained somewhat less damage.

The biological factors affecting the proportions of legumes and grasses are inter-specific competition, shading, and probably certain internal physiological conditions induced in response to the environment. Brome grass and sweet clover made very rapid growth the second season which resulted in the creation of a so-called micro- climate[3] near the ground. This was undoubtedly injurious to Dutch clover. Injury from this cause and from shading affected also to a lesser extent the two grasses, slender wheat and crested wheat. Neither Kentucky blue grass, alfalfa nor Altaswede red clover appeared to be damaged in this way.

In late summer the three grasses, slender wheat, crested wheat and Kentucky blue, particularly the first two species, exhibited a reduced rate of growth which seriously affected their productiveness, and hence reduced their contribution to the grass portion of the legume-grass ratio. Vinall and Hein (*12*) report that this period of reduced growth occurs in most grasses coincident with, or directly after, the time of the year when these plants normally produce seed. Hence, the common belief that the reduced growth rate of plants in late summer is due to drought alone appears to be erroneous. This phase of the work will be discussed more fully in the section dealing with earliness and activity of growth.

The proportion of legumes was probably reduced in one or two cases as a result of crowding out by the tall-growing brome grass. This apparently took place in pasture D in the case of Dutch clover in 1933. The vigorous growth of sweet clover the previous year was undoubtedly also a contributing factor in crowding out the Dutch clover. The dominant character of alfalfa in this regard is clearly seen in the results from studies of pastures A and E. This species appears to exhibit very great and rapid regenerative powers. Even in the drier latter part of the season, it seemed to grow at a normal rate, which is very important from the standpoint of production of late pasturage.

Mechanical factors affecting the legume-grass ratio were: clipping, grazing and trampling by live stock. No attempts were made to study the effects of grazing and treading by the cattle on the proportions of legumes

[3] Tall growing plants such as brome grass and sweet clover alter the atmospheric conditions near the ground by excluding sunlight and by cutting down evaporation from the soil and plant surfaces. The dampness which results after a heavy rain, in the absence of sunlight, often causes decay of vegetative parts of the plant. This altered atmospheric condition near the ground surface has been referred to by some investgiators as a micro-climate.

and grasses in the herbage. However, it might be inferred that grazing is not unlike cutting in its effects. The effect of cutting on the growth of grasses is clearly shown in the decrease in the quantities contributed by slender wheat and crested wheat grasses. Cutting did not seem to reduce, markedly, the proportions of alfalfa, Altaswede red clover and Kentucky blue grass.

Earliness and Periods of Active Growth

Tables 15 to 19 contain data on the various species collected at intervals during the growing season. Measurements were made on the material growing on the clipped areas within the fenced enclosures, and also on the growing plants on the pastured areas. Immediately following the measurements taken in the enclosures, the clipped areas were cut and new growth was allowed to take place for subsequent measurements.

It is generally recognized that certain species exhibit a more rapid early, continuous or late growth than others; also that certain species have a period of maximum growth and a period of relatively slower growth (Fenton *3*, *4*, and Vinall and Hein, *12*). These phenomena have an important bearing on the productivity of pasture mixtures during different periods of the growing season. It was in the hope of throwing some light on this problem that heights of plants in each pasture were measured at various times during the pasture season.

The results of these height measurements (Tables 15 to 19) indicate that, in general, the grasses were more rapid growers early in the growing season than the legumes. Brome grass was the earliest and most rapid grower in the spring, and it persisted in a state of relatively good growth in spite of repeated defoliations, until cold weather arrived. Next in earliness and persistency of growth was crested wheat grass. The growth of this species seemed to be less inhibited by drought in late summer than brome. Incidentally, this grass, where cut or closely grazed, also con-

TABLE 15.—AVERAGE HEIGHTS IN INCHES OF PLANTS OF VARIOUS SPECIES

Pasture A

Dates of measurements		Brome grass	Crested wheat grass	Slender wheat grass	Kentucky blue grass	Alfalfa	Sweet clover	Alsike clover
1932								
*May 26	Pasture	18.0	15.0	14.3	12.5	12.4	12.0	8.6
July 11	Enclosure	54.8	41.3	48.6	36.3	35.2	51.7	34.2
Aug. 30	Enclosure	19.0	15.6	13.8	11.7	16.0	19.0	5.6
1933								
May 6	Pasture	4.0	3.5	3.5	2.0	2.0	None	1.5
June 5	Enclosure	20.5	14.9	14.7	12.7	13.5	None	8.5
July 13	Enclosure	21.4	19.6	19.0	16.3	18.3	None	14.9
Aug. 29	Enclosure	11.1	6.8	10.0	8.9	16.3	None	5.8
1934								
April 28	Pasture	3.1	2.6	2.8	1.6	1.6	None	1.0
June 8	Enclosure	18.8	9.7	8.0	17.4	13.1	None	9.5
July 24	Enclosure	11.8	7.3	7.5	7.8	15.0	None	8.5
Sept. 8	Enclosure	4.8	–	–	3.3	10.4	None	2.3

*Height measurements were not taken on this pasture in the early spring of 1932.

TABLE 16.—AVERAGE HEIGHTS IN INCHES OF PLANTS OF VARIOUS SPECIES

Pasture B.

Dates of measurements		Slender wheat grass	Timothy	Altaswede red clover	Alsike clover
1932					
May 5	Pasture	3.9	4.8	1.8	2.2
June 4	Pasture	15.3	16.0	8.7	10.3
July 5	Enclosure	42.5	40.6	22.9	25.9
Aug. 27	Enclosure	17.6	21.3	8.3	9.3
1933					
May 6	Pasture	4.0	3.0	2.0	2.0
June 6	Enclosure	13.7	16.4	7.6	7.9
July 15	Enclosure	18.3	19.5	13.4	13.4
Sept. 1	Enclosure	7.9	7.5	6.1	5.6
1934					
April 28	Pasture	2.2	1.5	1.3	No growth

TABLE 17.—AVERAGE HEIGHTS IN INCHES OF PLANTS OF VARIOUS SPECIES

Pasture C

Dates of measurements		Brome grass	Kentucky blue grass	Alfalfa	Dutch clover
1932					
May 5	Pasture	6.6	4.2	3.3	2.2
June 9	Pasture	26.1	20.1	15.5	10.0
July 2	Pasture	48.1	31.4	28.1	20.8
1933					
May 6	Pasture	4.0	3.0	3.0	No growth
1934					
April 28	Pasture	3.6	2.3	2.3	None

TABLE 18.—AVERAGE HEIGHTS IN INCHES OF PLANTS OF VARIOUS SPECIES

Pasture D

Dates of measurements		Crested wheat grass	Brome grass	Kentucky blue grass	Dutch clover	Sweet clover
1932						
May 5	Pasture	7.3	7.5	3.9	2.4	2.3
June 11	Pasture	19.3	26.4	23.8	11.7	18.3
July 2	Pasture	32.0	47.3	32.3	18.5	35.0
July 7	Enclosure	37.3	50.0	36.4	21.8	45.3
Aug. 29	Enclosure	16.3	18.3	12.7	7.5	19.9
1933						
May 6	Pasture	3.5	4.0	2.0	1.0	None
June 9	Enclosure	15.0	18.2	12.3	5.3	None
July 14	Enclosure	14.7	15.6	9.7	5.7	None
Aug. 30	Enclosure	6.9	7.8	5.8	2.6	None
1934						
April 28	Pasture	2.7	3.0	1.9	No growth	None
June 9	Enclosure	10.3	13.2	12.3	3.5	None
July 28	Enclosure	8.6	8.2	4.8	4.5	None

TABLE 19.—AVERAGE HEIGHTS IN INCHES OF PLANTS OF VARIOUS SPECIES
Pasture E

Dates of measurements		Crested wheat grass	Kentucky blue grass	Alfalfa	Dutch clover
1932					
*May 25	Pasture	13.8	8.5	7.5	4.6
July 9	Enclosure	36.5	33.1	28.4	19.6
Aug. 31	Enclosure	21.7	12.1	19.1	6.4
1933					
May 6	Pasture	3.0	3.0	2.0	1.0
June 9	Enclosure	20.5	16.5	14.4	5.9
July 16	Enclosure	19.1	15.0	18.6	No growth
Sept. 4	Enclosure	8.5	7.4	11.1	No growth
1934					
April 28	Pasture	2.8	1.7	1.5	None
June 4	Enclosure	13.2	12.8	11.1	None
July 26	Enclosure	12.4	7.8	18.3	None
Sept. 9	Enclosure	4.9	3.3	10.1	None

*Height measurements were not taken on this pasture in the early spring of 1932.

tinued in a state of active growth late in the fall, as evidenced by both its height and greenness of colour long after brome and slender wheat grasses had been killed by heavy frosts. Timothy was apparently the third most important grass species from the standpoint of earliness and persistency of growth. Its growth appeared to be injured less by clipping than crested wheat grass, but it proved to be more susceptible to drought injury. Kentucky blue grass fell into fourth place in activity and persistency of growth. This species while it was not as early a producer of pasturage, was nevertheless only slightly behind the other grasses in persistency of growth late in the season. In periods of drought this grass appeared dry and dead, but as soon as a shower of rain came it was observed to spring up rapidly and produce green, succulent pasturage, indicating pronounced regenerative powers. Similar observations are reported by Fink, Mortimer and Truog (*5*) and by Hein and Vinall (*7*).

The legumes, as already stated, did not make as rapid growth in the spring as the grasses. However, certain of them, particularly alfalfa, persisted in a state of active growth quite late in the summer and early fall in spite of drought. Of the legumes seeded, alfalfa is shown to have made the most rapid early and late growth. In the middle of, and late in, the season sweet clover exceeded alfalfa in rapidity of growth. Among the legumes, next to alfalfa in production of early spring growth would seem to be Dutch clover, although the difference between the latter and sweet clover in this regard (Table 18) is scarcely significant. Further work is necessary to establish this point definitely. Continued rapid growth of alfalfa late into August is also reported by Vinall and Hein (*12*). Alsike comes fourth and Altaswede red clover last in earliness of growth. In persistency and lateness of growth these clovers seem to be equal, and come third, with Dutch clover last in this regard. In 1932 sweet clover was shown to have made the greatest fall growth, far exceeding alfalfa. By 1933 the sweet clover had disappeared.

Figure 3 serves to convey some idea of the amount and rapidity of growth in 1932 for the five pastures studied.

Palatability of Various Species as Indicated by the Selectivity of Grazing Animals

This investigation was not undertaken with any intention of including observations on the relative palatability of the various species included in the mixtures. This aspect warrants a separate study. However, in taking general notes on the pastures from time to time, it was observed that plants of certain species were grazed very closely while others were left almost untouched. This led the writers to take a few critical notes on the selectivity of the grazing animals. These notes have been supplemented with photographs (Figures 4 and 5) of one pasture illustrating typical selectivity.

Observations showed that the more palatable species (those readily eaten by the cattle) were Kentucky blue grass, Dutch clover, Alfalfa, alsike clover, timothy, brome grass and Altaswede red clover, in the order named. The apparently unpalatable species (less readily eaten) were in descending order of palatability: sweet clover, slender wheat grass and crested wheat grass. The photographs (Figures 4 and 5) illustrate the high palatability of Kentucky blue grass and the apparent unpalatability of crested wheat grass. These observations are not entirely in agreement with results reported by Stapledon (*10*). He found timothy and wild white clover to rank highest in palatability among the species studied by him.

There might be objection to these conclusions on the grounds that in 1932 the species were well advanced in their growth when pasturing was begun in the spring, at which time the different species being in different stages of growth would on this account, show differential palatability. This objection would no doubt be justified. However, the authors, as a result of their observations over the three years, believe that their conclusions regarding the relative palatability of these species are not far wrong under the conditions of the investigation.

GENERAL CONCLUSIONS

The object of this investigation was to study changes that might take place in the vegetative composition of the pastures, and the relative survival and productivity of the different species in different mixture combinations.

It may be well to point out that the results obtained have not been presented with the idea that they are conclusive or that the objects of the investigation have been fully realized. Certain of the results do, however, appear to be significant; for example, changes in the floral composition of the pasture mixtures were very evident. Certain species were found to possess short survival value while others persisted under the conditions of the investigation, and considerable variability was exhibited in the productivity of different mixtures and difference species. Brome, Kentucky blue grass and alfalfa appeared to be the most valuable perennial species used in the mixtures, from the standpoints of persistence, adaptability and productiveness. Alsike clover, Altaswede red clover, Dutch clover, crested wheat and slender wheat grasses were less persistent and less productive. Observations on palatability indicated that Kentucky blue grass, Dutch clover, alfalfa and alsike clover were the more palatable species, while slender wheat and crested wheat grasses were the least palatable, with other species being intermediate.

FIGURE 1. A test strip-area. The flat stakes shown are two inches wide, are placed six feet apart and mark off strip-areas in the pasture for periodic counting of plants.

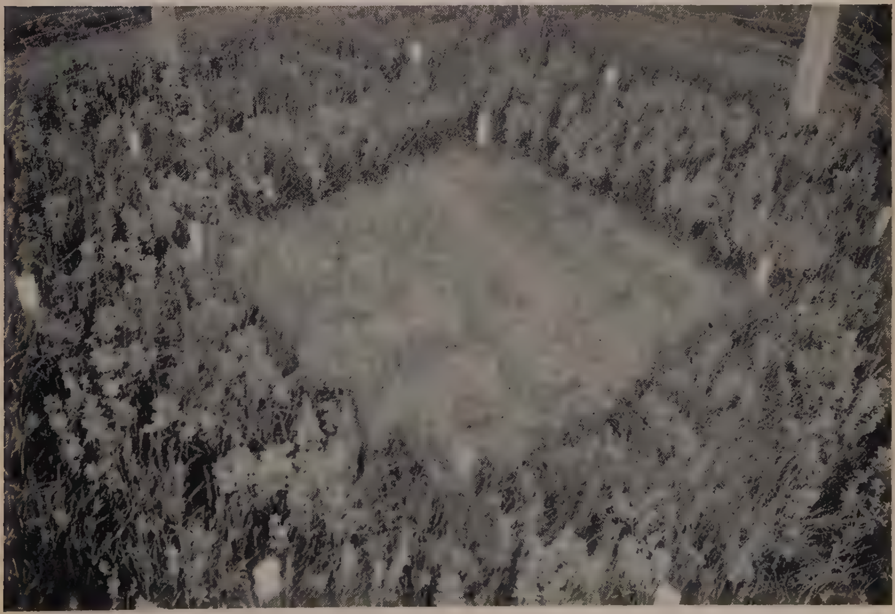

FIGURE 2. A test enclosure. The flat stakes shown are six feet apart and mark off strips for the periodic counting of plants. The central area is six feet square, and was cut for yield determinations.

FIGURE 3. The sheaves shown represent composite samples drawn from the cut herbage of each of the five pastures when the first cutting was taken in 1932. They serve to illustrate in a general way the botanical composition of each pasture mixture, and the relative heights of constituent plants at the time of cutting.

The dates of cutting and heights in inches of sheaves are as follows:

Pasture	*Date of cutting*	*Maximum height in inches*
A = I	July 13	48
B = II	July 16	46
C = III	July 13	53
D = IV	July 16	52
E = V	July 16	36

FIGURE 4. A photograph illustrating the selectivity of cattle in grazing. The ungrazed grass is crested wheat grass. The photograph was taken of a spot chosen at random in pasture E on October 11, 1933.

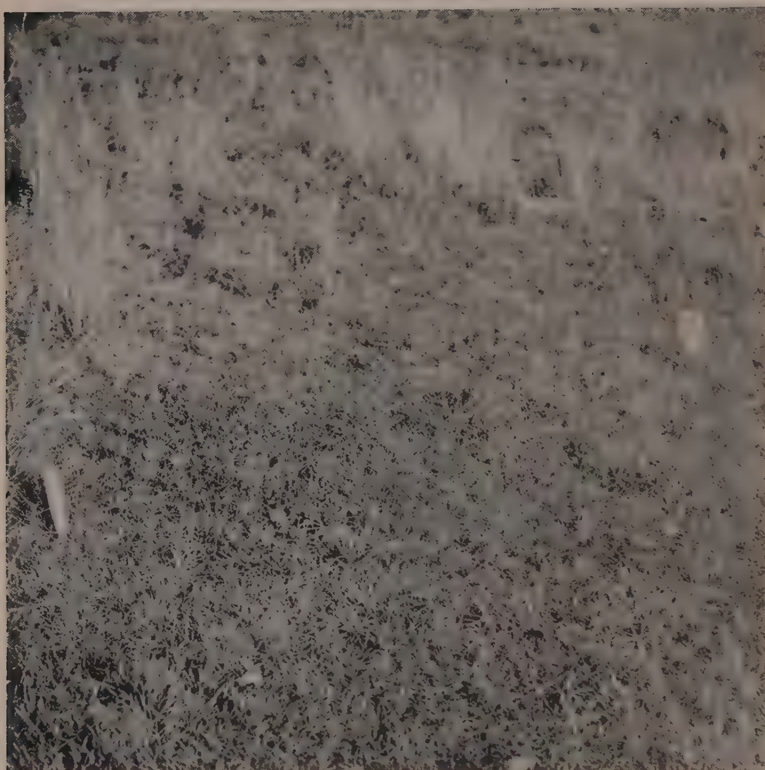

FIGURE 5. The photograph illustrates the close grazing of Kentucky blue grass and alfalfa, and the avoidance of crested wheat grass. The stakes shown are approximately 4 inches above the ground level. The photograph was taken of one of the strip-areas in pasture E on October 11, 1933.

The data presented and the general observations would seem to suggest that brome would be an excellent pasture grass in areas of periodic drought, similar to those common to Edmonton. Crested wheat grass is apparently not well suited to pasture mixtures, even though it is highly drought-resistant, as repeated defoliations seemed to cause its rapid killing out. Moreover, cattle avoid grazing it almost entirely, except in the spring and early summer when all growth is tender and succulent. Timothy was injured less by clipping than crested wheat grass, but it proved to be more susceptible to drought. On the whole, it is much to be preferred to crested wheat grass in mixtures for pastures for our conditions. Slender wheat grass did not give promise of a good or even fair pasture grass, as it declined rapidly with repeated defoliations, and it appeared to be exceeded in unpalatability by crested wheat grass only. Kentucky blue grass gave indications of being a very desirable constituent of pasture, due to its colonizing and regenerative powers and its high palatability. Of the legumes, alfalfa appeared to be particularly suitable for pasture, although some deterioration occurred, probably due to winter killing and possibly to crowding. Sweet clover was found to be of value only in the first harvest year. Altaswede red clover is undoubtedly better suited for hay than for pasture. Alsike clover appears to be a good pasture species where the land is low and damp. It does not compete successfully with Altaswede on higher ground. Dutch clover was the most disappointing of all the legumes because of its complete killing out in the third year.

Pasture C undoubtedly represents a good mixture. More care should be exercised in the method of seeding brome grass, however. Replacement of the white Dutch clover by three pounds of alsike clover seed per acre is suggested. Pastures A and E have been shown to be almost equal in regard to productivity and quality of herbage, with the balance in favor of E. It should be recalled here (see Table 8), however, that alfalfa in pasture E had been almost completely killed out in 1934 in the pasture proper, while in the enclosures it still survived.

The results from Pasture B are not as indicative of high productivity and quality of pasturage as might be expected. It seems doubtful if alsike and Altaswede clovers in mixtures with grasses are desirable constituents of pastures. The need for alfalfa in the mixture was brought out clearly in the results. Also timothy became very fibrous and brown in appearance in August unless pastured very closely. The studies on pasture F showed that alfalfa and brome grass grow well together, and the former was not markedly injured by continuous grazing in this pasture. A general thickening of the stand had occurred by 1934.

The weed flora appeared to have been reduced in all the pastures, except in pasture E in 1934, when Russian pigweed had increased markedly and had occupied all former bare areas and paths. An explanation for its presence is not evident. Apparently the seeds had been dormant in the soil since before seeding in 1931. Few weeds were observed to have gone to seed in the other pastures.

The most outstanding results of the investigation were, perhaps, the gradual disappearance of both slender wheat and crested wheat grasses, and the almost complete killing out of Dutch clover. The contribution by these two grass species to the grass portion of the legume-grass ratio was at no time more than barely significant, indicating that their dis-

appearance does not alter markedly the productivity of the mixtures in which they were included. A second striking result is the apparent amicable growing relations between brome grass, Kentucky blue grass and alfalfa.

The determination of a pasture mixture or mixtures suitable to existing conditions of soil and climate in the Edmonton district is obviously of great economic importance to farmers. Hitherto, no such mixture has been available and no work has been reported in Canada, so far as the writers are aware, which offers any dependable guidance. The results of these investigations may serve as some guide in compounding perennial pasture mixtures for conditions similar to those of the Edmonton district.

SUMMARY

1. The better seed mixtures for perennial pastures were those containing alfalfa, brome grass and Kentucky blue grass. These species were characterized by high productivity, high palatability, amicable growth association with one another, and by strong resistance to drought, cold and defoliation. The poorer, short-duration mixtures contained sweet clover and Dutch clover, but no alfalfa.

2. Dutch clover had disappeared almost completely by the beginning of the third season after seeding. This was believed to be due mainly to the shading and crowding effects of the tall-growing brome grass and sweet clover.

3. Altaswede red clover had decreased less than alsike clover. Both of them, however, showed rapid decreases in frequency. These plants, under the conditions of the investigation, were not entirely satisfactory pasture species. This is believed to be due to their sensitivity to adverse factors, e.g., drought and plant competition.

4. Slender wheat grass showed rapid decreases in its frequency from 1932 to 1934, due, probably, to the injurious effect of repeated defoliations and the apparently short-life duration of this species. Crested wheat grass also showed rapid decreases in its frequency, except in pasture E, where its decrease was less marked. This species also proved to be comparatively unpalatable. Thus it would seem that these species are not very satisfactory for pasture purposes in the Edmonton area.

5. Timothy, while it was not injured by drought and repeated defoliations, appeared to be more suitable as a hay than as a pasture plant, as indicated by its rank culm growth, and its tendency towards head production.

6. Sweet clover was of value in the mixture only up to the middle of the second summer because of its biennial habit of growth, and the dry conditions in the latter part of this season. The objectionable features of this plant for pasture purposes were its coarseness and short-life period.

7. Weeds were kept well in check and appeared to be decreasing in frequency, except in pasture E in 1934, where the frequencies of weeds had increased. Stinkweed was very troublesome in the first year, but it showed a rapid decrease from year to year.

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Résumé

Une étude botanique des mélanges à pâturages. W. C. Stone et J. R. Fryer Université de l'Alberta, Edmonton, Alberta.

Les meilleurs mélanges de semences pour les pâturages vivaces sont ceux qui contiennent de la luzerne, du brome inerme, et du pâturin bleu du Kentucky. (Pâturin des prés). Ces espèces se sont caractérisées par une haute productivité, une bonne succulence, une bonne tolérance végétative les unes envers les autres et une haute résistance à la sécheresse, au froid et à la défeuillaison. Les mélanges plus pauvres, de courte durée, contenaient du mélilot et du trèfle de Hollande, mais pas de luzerne. Le trèfle de Hollande avait disparu presque complètement vers le commencement de la troisième saison après les semailles. On attribue cette disparition en grande partie à l'ombrage et à l'effet étouffant exercé par le grand développement du brome inerme et du mélilot. Le trèfle rouge Altaswede a diminué moins que le trèfle d'alsike. Tous deux, cependant, montrent des diminutions rapides de fréquence. Dans les conditions de cette enquête ces plantes ne se sont pas montré très bonnes pour le pâturage. On croit que c'est à cause de leur sensibilité aux facteurs adverses comme la sécheresse et la concurrence faite par les autres plantes. L'agropyre grêle (Ray-grass de l'Ouest) a exhibé des diminutions rapides de fréquence de 1932 à 1934, sans doute à cause de l'effet nuisible des défeuillaisons répétées et de la durée apparemment courte de cette espèce. L'agropyre à crête exhibait aussi des diminutions rapides de fréquence, sauf dans le pâturage "E" où sa diminution était moins marquée. Cette plante s'est aussi montrée assez peu savoureuse et c'est pourquoi il semble que ces espèces ne sont pas très satisfaisantes pour les pâturages dans la région d'Edmonton. Le mil, qui cependant n'a pas été affecté par la sécheresse et les défeuillaisons répétées, paraît faire une meilleure plante à foin qu'à pâturage, ainsi que l'indique la végétation épaisse de ses tiges et sa tendance à la production des épis. Le mélilot n'était utile dans les mélanges que jusqu'au milieu du deuxième été à cause de son mode bisannuel de végétation et des conditions de sécheresse pendant la dernière partie de la saison. Les désavantages de cette plante pour le pâturage sont sa grossièreté et son peu de durée. Les mauvaises herbes ont été bien tenues en échec et leur production paraissait décroître, sauf dans le pâturage "E" en 1934 où leur fréquence avait augmenté. Le tabouret a causé beaucoup d'ennui la première année, mais il a diminué rapidement depuis lors d'une année à l'autre.

PHYSIOLOGIC SPECIALIZATION IN *PUCCINIA CORONATA AVENAE*[1]

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INTRODUCTION

Crown rust of oats (*Puccinia coronata Avenae* Erikss. and Henn.) occurs to some extent in Canada almost wherever oats are cultivated. It is of considerable economic importance in Eastern Canada, where it often causes severe losses. In Manitoba and Saskatchewan, it usually does not cause appreciable damage, except where oats are grown in proximity to buckthorn (*Rhamnus cathartica* L.) hedges, but in 1927 it did occur in epidemic form in these two provinces. It is of very minor importance in Alberta and British Columbia.

Hoerner (*1*), who was the first to demonstrate physiologic specialization in *P. coronata Avenae*, isolated four forms in 1919. He distinguished these forms by the types of infection that they produced on two differential oat varieties, Ruakura and Green Russian. A few years later, in 1926, Popp (*8*) isolated four forms of crown rust from collections obtained in Eastern Canada. He could not determine definitely whether or not the forms which he isolated were similar to those reported by Hoerner, as he was not certain that the strain of Ruakura which he used was identical with the strain of that variety used by Hoerner. In 1927, Parson (*5*) studied collections of crown rust, which he obtained from various localities in the United States, and succeeded in isolating five distinct physiologic forms. The differential hosts which Parson used differed from those used by Hoerner and by Popp, and consequently he was unable to compare the forms which he isolated with those reported by them. Using a set of differential hosts, which included all the varieties used by these workers, the writer (*7*), in 1929, isolated eight physiologic forms of crown rust. Five of these forms differed from the forms reported earlier. In the same year Frenzel (*2*) isolated thirty-five forms of crown rust of oats from collections made in Germany, and Murphy (*3*), nine forms from collections made in the United States. Later, Murphy (*4*) isolated 33 physiologic forms of crown rust of oats from collections obtained in the United States, Canada and Mexico. He showed that the 33 forms identified by him embraced all the forms that had been isolated by Hoerner, Popp, Parson and Peturson, and proposed a standardized numerical designation for the 33 forms.

Unfortunately, no standard set of differential hosts has, up to the present, been generally adopted by those engaged in the identification of physiologic forms of crown rust of oats, as has been done with so much advantage in studies of physiologic specialization in both stem rust of wheat and of oats. With a view of remedying, at least partially, this

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situation, Dr. H. C. Murphy, who is in charge of crown rust investigations for the United States Department of Agriculture, and the writer agreed in 1931 to adopt a standard set of differential hosts for the identification of physiologic forms of crown rust in the United States and Canada. Table 1 gives the list of differential varieties selected.

Table 1.—List of differential varieties

Avena byzantina		*Avena sativa orientalis*	
Sunrise	C.I. 982	Green Mountain	C.I. 1892
Belar	C.I. 2760	White Tartar	C.I. 551
Red Rustproof	C.I. 1815		
Sterisel (Sterilis Selection)	C.I. 2991		
Avena sativa		*Avena strigosa*	
Ruakura Rustproof	C.I. 2025	Glabrosa	C.I. 2630
Green Russian	C.I. 2890		
Anthony	C.I. 2143		
Hawkeye	C.I. 2264		

The present study deals with the identification, prevalence, and geographic distribution of physiologic forms of crown rust of oats isolated from collections of crown rust obtained in a number of widely separated localities in Canada.

FIELD AND LABORATORY STUDIES

Identification of Forms

The various physiologic forms of crown rust of oats are apparently identical morphologically, and, as with the other cereal rusts, their identification is based on the types of infection which they produce on a set of oat varieties selected as differential hosts. In differentiating the physiologic forms of crown rust, the classes of host reactions and types of infection described by Stakman, Bailey and Levine (*9*) for stem rust of oats have been used.

An analytical key for the identification of all the physiologic forms of *P. coronata Avenae* which have been isolated in the present study is given in Table 2.

Table 2.—Analytical key for the identification of physiologic forms of *Puccinia coronata Avenae* determined on the basis of their parasitic behaviour on differential varieties within the genus *Avena*.

Glabrosa susceptible	
Green Russian susceptible	Form 24
Green Russian resistant	A
Glabrosa resistant	
Green Russian susceptible	
Ruakura susceptible	
Green Mountain susceptible	1
Green Mountain resistant	10
Ruakura resistant	
Red Rustproof resistant	3
Red Rustproof susceptible	6
Green Russian resistant	
Belar susceptible	
Ruakura susceptible	4
Ruakura resistant	
Red Rustproof susceptible	5
Red Rustproof resistant	B
Belar resistant	
Green Mountain susceptible	9
Green Mountain resistant	2

In the analytical key presented here, certain differential varieties were omitted. The reason is, that their reactions are identical with those mentioned in the key. Green Russian gives the same reactions as Anthony, Green Mountain as White Tartar, and Red Rustproof as Sterisel and Sunrise. Hawkeye is omitted as it is susceptible to all of the eleven forms.

During the first year of the investigation, forms were identified at ordinary greenhouse temperature. While the work was in progress considerable fluctuations in temperature occurred from time to time. In 1930 the writer (*6*) showed that the types of infection produced by some of the forms on certain of the differential hosts were greatly modified by the temperature at which the cultures were kept during the period of incubation. He found that the types of infection produced by forms 1 and 3 were not appreciably modified by temperature, but that the infection type produced by form 4 (form 6 of the present system of classification) on Red Rustproof was slightly modified by temperature, and that the infection types produced by form 7 (form 4 of the present system) on Green Russian, Green Mountain and White Tartar varied from a O-type at 57° F. to a 4-type at 77° F. It seemed therefore highly desirable that for the identification of forms the differential hosts be kept during the period of incubation at approximately the same temperature. Consequently, in all subsequent work an attempt was made to maintain a moderately uniform temperature. The rust reactions recorded in this paper for the differential varieties are those produced at a temperature within the range of 60° to 65° F.

During the six-year period, 1929 to 1934, five hundred and forty-four collections of crown rust of oats, obtained from various localities in Eastern and Western Canada, were studied in the greenhouse. From these collections eleven distinct physiologic forms were isolated. The reactions of the differential varieties to all the forms isolated in the present study are given in Table 3.

TABLE 3.—THE REACTIONS AT 60°–65° F. OF THE ELEVEN DIFFERENTIAL VARIETIES TO THE ELEVEN PHYSIOLOGIC FORMS OF CROWN RUST ISOLATED IN CANADA

Differential host	Physiologic form										
	1	2	3	4	5	6	9	10	24	A	B
Hawkeye, C.I. 2264	4	4	4	4	4	4	4	4	4	4	4
Green Russian, C.I. 2890	4	0	4	0	0	4	2	4	4	0	0
Anthony, C.I. 2143	4	0	4	0	0	4	2	4	4	0	0
Green Mountain, C.I. 1892	4	0	4	0	0	4	4	1	4	0	0
White Tartar, C.I. 551	4	0	4	0	0	4	4	1	4	0	0
Ruakura, C.I. 2025	4	0	0	4	0	0	1	4	0	0	0
Sterisel, C.I. 2991	4	0	0	4	4	4	1	4	0	0	0
Red Rustproof, C.I. 1815	4	0	0	4	4	4	1	4	0	0	0
Sunrise, C.I. 982	4	0	0	4	4	4	1	4	0	0	0
Belar, C.I. 2760	4	0	0	4	4	4	1	4	0	0	4
Glabrosa, C.I. 2630	0	0	0	0	0	0	0	0	4	4	0

Prevalence of Forms

As already stated, collections of crown rust were obtained from different parts of Canada during the years 1929 to 1934. Table 4 gives for each of these years the number of isolations made of each form. It will be seen that some of the forms were of common occurrence and recurred year after year, while others were rare or only appeared for one season.

TABLE 4.—THE NUMBER OF ISOLATIONS OF EACH FORM MADE EACH YEAR DURING THE PERIOD 1929 TO 1934

Physiologic Form	Year						Total
	1929	1930	1931	1932	1933	1933	
	Number of isolations						
1	38	24	32	28	8	14	144
2	2	22	14	24	15	15	92
3	32	52	24	18	26	10	162
4	3	5	23	20	4	20	75
5	0	0	1	0	0	0	1
6	10	13	4	4	11	0	42
9	3	0	0	0	0	0	3
10	15	0	0	0	0	0	15
24	0	1	3	2	0	1	7
A	0	0	0	0	2	0	2
B	0	0	0	0	1	0	1
Total	103	117	101	96	67	60	544

Distribution of Forms

The geographic distribution of the physiologic forms of crown rust of oats identified during the period 1929-34 is given in Table 5.

Table 5 shows that some of the forms occurred both in Eastern and Western Canada, while others occurred only in the one or the other of these geographic divisions. The most prevalent forms, namely, forms 1,

TABLE 5.—THE RELATIVE PREVALENCE OF PHYSIOLOGIC FORMS IN EASTERN AND WESTERN CANADA EXPRESSED IN PERCENTAGES OF TOTAL COLLECTIONS IDENTIFIED FROM EACH REGION DURING THE PERIOD 1929–1934

Physiologic form	Western Canada						Eastern Canada					
	1929	1930	1931	1932	1933	1934	1929	1930	1931	1932	1933	1934
	Percentage						Percentage					
1	39.7	37.5	49.1	43.6	18.6	38.7	28.0	0.0	9.0	9.7	0.0	6.8
2	0.0	1.5	3.5	3.6	0.0	0.0	8.0	39.8	27.2	53.6	62.5	51.7
3	25.6	40.6	8.8	12.8	44.2	0.0	48.0	49.1	43.3	26.9	29.2	34.5
4	3.9	4.7	35.0	34.6	9.3	61.3	0.0	3.7	6.8	2.5	0.0	3.5
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0
6	8.9	15.7	1.8	5.4	25.6	0.0	12.0	5.5	6.8	2.5	0.0	0.0
9	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	19.4	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	1.8	0.0	0.0	0.0	0.0	1.8	2.3	4.8	0.0	3.5
A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	8.3	0.0
B	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0

2, 3, 4, and 6 belong to the first-mentioned group. The relative prevalence of these forms varied considerably from year to year, but, in general, forms 1 and 4 were much more common in Western than in Eastern Canada, while the converse is true of form 2. Forms 3 and 6 were about equally prevalent in both areas.

SUMMARY

1. Eleven physiologic forms of crown rust of oats have been isolated from collections of this rust obtained in various parts of Canada.

2. Several of the forms were of common occurrence and were present year after year while others were quite rare.

3. The commonly-occurring forms were collected both in Eastern and Western Canada. Certain forms predominated in the East while others were more prevalent in the West.

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Résumé

Spécialisation physiologique dans puccinia coronata avenae. B. Peturson, Laboratoire fédéral de recherches sur la rouille, Winnipeg, Man.

Onze formes physiologiques de rouille couronnée de l'avoine ont été isolées des collections de cette rouille obtenues dans différentes parties du Canada.

Plusieurs de ce formes sont bien connues et reviennent tous les ans, tandis que d'autres sont très rares. Les espèces qui se rencontrent fréquemment ont été recueillies dans l'Est aussi bien que dans l'Ouest du Canada. Certaines formes prédominaient dans l'Est, tandis que d'autres étaient plus répandues dans l'Ouest.

THE "SEEDS" OF THE GENUS POA COMMONLY FOUND ON THE MARKET IN CANADA

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The object of this paper is not to give detailed descriptions of the "seeds" of the four species of Poa which are commonly found in commerce, but rather to point out those characters which may be most readily used by the seed analyst for distinguishing the species. Very careful descriptions have been made by Hillman[2] and others.

There are four species of Poa of commercial importance in Canada

1. *Poa pratensis* L. (Kentucky Blue Grass, Smooth-stalked Meadow Grass).
2. *Poa compressa* L. (Canada Blue Grass, Flat-stalked Meadow Grass).
3. *Poa trivialis* L. (Rough-stalked Meadow Grass).
4. *Poa nemoralis* L. (Wood Meadow Grass).

There is one other species, *Poa annua* L. (Annual Blue Grass or Meadow Grass), samples of which are occasionally found in the trade. It also appears as an occasional impurity in other grasses. In spite of the fact that it is considered by many turf growers to be an undesirable grass, there are occasional demands for the seed.

There is little difficulty in the identification of these species in pure bulk lots. The trouble arises when the seeds of these grasses appear as mixtures. The cheaper Canada Blue Grass is sometimes used as an adulterant of Kentucky Blue Grass. Three or four species are frequently found together in the higher-class lawn grass mixtures, so that it is necessary to make separations in order to determine the grade of the mixture under the Seeds Act.

Such characters as the extent of the basal web, pubescence, and length of rachillae, are not satisfactory. In commercial seeds the web and pubescence are often wanting, having been removed in the process of threshing and cleaning. There is one exception to this statement. The rachillae of *Poa nemoralis* are always more or less hairy. This seems to be a constant character and one which may be used to distinguish this species from the other three. The length of the rachilla can be used to a certain degree in combination with other characters, but naturally the variation in different seeds is very great. In *P. trivialis* and *P. nemoralis* a large proportion of rachillae of over one-half the length of the caryopsis may be found.

Colour can be used only to a limited extent as a distinguishing characteristic. When compared in quantity the seeds of *P. pratensis* generally appear to be darker than the others. *P. trivialis* is a little darker than either *P. compressa* or *P. nemoralis*. When determining the percentage

[1] Chief Seed Analyst.
[2] The Seeds of the Blue Grasses, E. Brown and F. H. Hillman, U.S.D.A. Bulletin 84, 1905.

of species persent in mixtures of *P. compressa* and *P. pratensis*, colour can be made use of as an assistance to identification especially when seeds of the upper florets are in question, or other seeds in which the teeth on the veins of the paleae are not exposed. *The seeds of Poa compressa are generally darker in colour toward the apex while those of Poa pratensis are generally darker at the base.*

The characters which are most useful for identification are:

(1) The "teeth" on the veins of the paleae. These teeth are stiff hairs. Hillman describes the veins or keels of the paleae as being "hispidcilliate".

(2) The characters of the lemmas.

(3) Presence of pubescence on the rachillae.

(1) The Teeth on the Veins of the Paleae

Poa pratensis: Conspicuous, broad at the base, well separated. (Figure 1, A.)

Poa compressa: Finer, close together especially towards the tips of the paleae. (Figure 1, B.)

Poa trivialis: Apparently often wanting, at least under lower power lens—always very small. (Figure 2, A.)

Poa nemoralis: Always present, very fine and hard to see unless the light is catching the seed correctly. (Figure 2, B.)

(2) Characters of the Lemmas

P. pratensis: Sharply keeled; lemma larched (side view); *intermediate veins generally distinct*, especially when the seed is lying on its side; apex acute, margins not markedly infolded, only partially covering the veins of the palea. (Figure 3.)

Poa compressa: Not sharply keeled; lemma not markedly arched (side view); *intermediate veins indistinct or wanting*, however, in occasional seeds they are quite marked; apex generally obtuse with margins widely spreading. (Figure 4.)

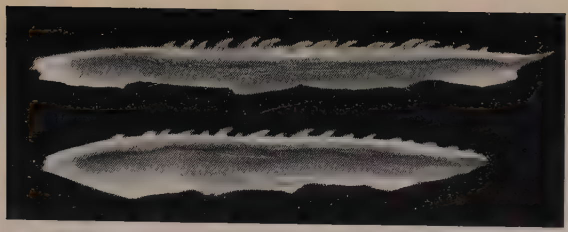
P. trivialis: Sharply keeled; lemma very strongly arched (side view); *intermediate veins very distinct*, particularly when seed is lying on its side; apex sharply pointed; margins of lemma infolded covering the veins of the palea often over half its length (Figure 5.)

Poa nemoralis: Not so sharply keeled; lemma not strongly arched (side view); intermediate veins almost wanting; apex acute; margins of lemma very much infolded. (Figure 6.)

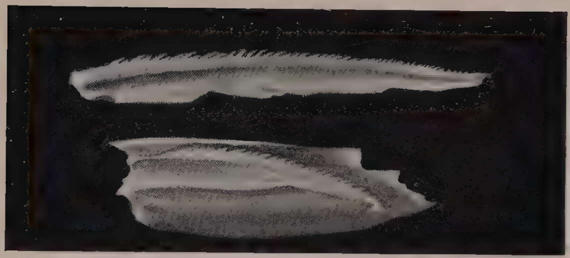
(3) Pubescence of Rachilla

A constant character of P. nemoralis only: often very short on the long rachillae of the upper florets when it might be described as puberulence. (Figure 6.)

The analyst who has the opportunity of frequently examining these seeds will, to use Hillman's words, "get his eye in" and identify the species with remarkable accuracy by general appearance, using special characters when in doubt. The less experienced analyst will probably use the characters of the "teeth" as a very sure means of identification in combination

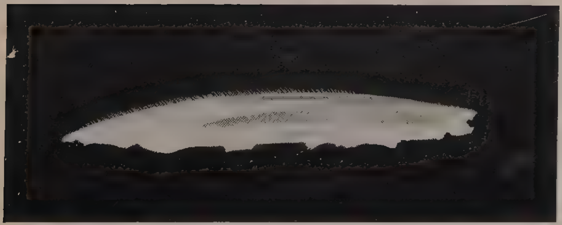


A
Fig. 1—Poa pratensis.



B
Fig. 1—Poa compressa.

A
Fig. 2—Poa trivialis.



B
Fig. 2—Poa nemoralis.

Fig. 3—Poa pratensis.

Fig. 4—Poa compressa.

FIG. 5—Poa trivialis

FIG. 6—Poa nemoralis.

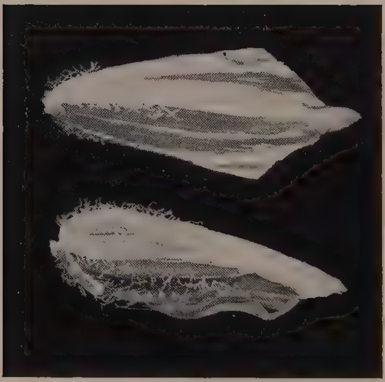


FIG. 7—Poa annua.

with the distinctness of the intermediate veins, etc. Seeds such as those shown in Figure 3x and Figure 4x are difficult to distinguish by the general appearance and the intermediate veins. Figure 4x shows a quite sharply pointed type of *P. compressa* which has the intermediate veins much more sharply defined than is normal. The teeth on the palea would be the determining factor in this case.

Poa Annua. The "seeds" of Poa annua (Figure 7) are quite characteristic, so much so that there should be no difficulty in distinguishing them from the four species already mentioned. They are robust, strongly keeled and arched. The keels and marginal veins of the lemmas are more or less densely pubescent. The intermediate veins are very distinct and are sometimes pubescent, as is also the surface between the veins. The lemmas are very narrowly infolded below the middle, broadly hyaline above, and flaring. The keels or veins of the palea are coarse and densely pubescent, much arched and exposed from side view.

NOTE: Drawings approximately 14 times size of seed.

A STUDY OF THE CAUSES OF "BLAST" IN OATS

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The term "blast", as related to oats, has been given to a type of sterility commonly found in this crop and which presumably reduces the yield considerably. Oat blast manifests itself at the time of heading in the form of white, empty glumes particularly towards the base of the panicle. Sterility of this type has been reported by many workers under various terms, e.g., "blight", "blindness", "white ear", "blast", etc.

Among earlier reports on oat blast, the generally accepted opinion appeared to be that the injury was caused by insects. This conclusion was arrived at by workers both in Europe and America. In 1914, Hewitt (*7*) reported that sterility of this form was the result of injury caused by the grass thrip. Hewitt, in this paper briefly reviews the observations of several European workers who had found thrips responsible for spikelet injury in cereal crops. It is possible that the type of sterility referred to by these earlier workers did not conform to the injury now commonly called blast, although from descriptions given, it would seem to be identical.

Manns (*10*) working on blade blight of oats observed that there was close agreement between blasted spikelets and extent of blade blight. He pointed out that some blasted spikelets may be caused directly by a blight organism but that more often this sterility is brought about by reduced vitality of the plant as a result of blade blight.

Elliott (*3*) working with the halo blight organism, found no relation between this disease and the prevalence of blast. She concluded that sterility, known as "blast", was brought about by the presence of "too much moisture about developing panicles". This author also observed that varieties of oats possessed different amounts of sterility when grown under uniform conditions in the same year.

Roebuck (*13*), working in England, suggested from the available evidence that frit flies were the cause of "blindness" in oats.

Fryer and Collin (*6*) reported that "The percentage of sterile spikelets appears to have no correlation with either of the frit attacks and it is difficult to believe that this pest was in any way concerned in the production of blindness".

Cunliffe (*1*) and Cunliffe and Fryer (*2*), studying the infestation of frit fly in relation to sterility or "blindness" in oats, stated: "If this insect were responsible then percentage sterility should correlate with percentage infestation." No correlation however was found and these authors therefore conclude that frit flies played little or no part in causing "blindness" in oats.

Elliott (4) in a further paper reported that "Varietal differences in the amount of blast appear to be fairly constant from season to season." This author further observed that blast percentage was associated with precipitation during the month of heading and that varieties of hybrid origin were more susceptible to conditions causing blast.

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Huskins (*8*) reported the existence of "specific genetic resistance" to blast and from his data concludes that there is no physiologic relation between blast percentage and panicle size. He pointed out further that it should be possible to breed resistance to blast.

In a study of the inheritance of resistance to blast in oats Mackie (*9*) has shown that varietal resistance is fairly stable. In this work the F_2 progeny gave close agreement to a 1 : 2 : 1 ratio for highly susceptible, moderately susceptible and practical immunity. These results indicate that it is possible to breed for blast resistant varieties.

Considerable work on oat blast has been reported by Rademacher, who concluded in his most recent paper (*12*) that "This abnormality is attributed to defective nutrition at an early stage and may be increased by heavy rainfall, cool or cold weather; and in the case of oats which is a long day type, light deficiency may be a causal factor, but varietal differences probably exist also." In an earlier paper (*11*) this author discussed the effect of origin and environment of the parent seed on blast in the daughter plants. He pointed out that since water supply during the growth of the parent seed is reflected in the development of the progeny, then it might be expected that the environment of the parent seed might also influence the occurrence of blast in its progeny. In this connection, the author concluded that when the parent plants develop under dry conditions there is likely to be found greater resistance to drought in the progeny.

Results of investigational work on oat blast in recent years have therefore shown that sterility of this type is probably physiological. A general summary of recent literature on oat blast and a discussion on the probable causes of the injury is found in Sveriges Utsädesförenings Tidskrift (1932), Vol. 4, page 271. The author of this paper stated that "The damage arising through the presence of an appreciable percentage of empty glumes is not, as has been intimated, one of our most serious difficulties. It is, however, a symptom that the supply of plant food or the moisture conditions of the soil are not right." It was further suggested that choice of variety may also be a factor in the development of blasted spikelets.

OUTLINE OF INVESTIGATIONS

In 1932 a study of oat blast was begun in the Cereal Division, Central Experimental Farm, Ottawa, and in that year some preliminary work to show the effect of different water treatments on the occurrence of blast was carried out under field conditions.

In 1933 a project was outlined to determine the effect of different water and light treatments on the prevalence of oat blast. In the case of the water treatments, an attempt was made primarily to determine to what extent blast was influenced by the application of different amounts of moisture to the young oat plants and secondly to find the critical stage in the early growth of the crop at which different amounts of water would have the greatest influence on the production of blasted spikelets. This work was carried on under greenhouse conditions. On account of the loss of some plants in the water treatment series this part of the experiment was repeated during the winter of 1934-35. In conjunction with the water treatment series, an effort was made to ascertain the effect of different

combinations of light and water treatments on blast development. This work was also carried on in a greenhouse, where the environment, in so far as the factors of light[2] and moisture are concerned, is largely under control.

Data were obtained from the field in 1934 with regard to the influence of date of seeding on the development of oat blast.

Water Treatments

While no statistical analysis was made of the preliminary field work on the effect of different water treatments on blast, it was quite evident that some influence existed. These observations prompted further work. Later investigations were conducted both in the field and in the greenhouse.

In the field test the plants were grown in 10″ pots, which were set in the soil, level with the surface. The pots were divided into three lots, each lot containing 50 plants and subjected to a different water treatment, e.g. reduced water, normal water and excess water. In the case of the reduced water treatment, the plants were given drought conditions by protecting them from natural rainfall. In the normal treatment, the pots were left open to natural precipitation, while the excess treatment consisted of the application of 500 cc. of water to each pot every other day. The treatments started 24 days after seeding, the plants at this time having produced 4 leaves, all plants being given uniform water conditions up to the fourth leaf stage. It was found necessary to apply water twice to the reduced water lot during the course of the test period in order to prevent the plants from drying up completely. The treatments lasted until the appearance of the panicle on the main tiller, after which all three lots were given normal moisture conditions.

The above test was also carried on under greenhouse conditions during the winter of 1933-34. It was possible to control the treatments under glass much more accurately than was the case in the field, although only half the number of plants was used in each lot. The plants in this test were grown in 6″ pots with 5 plants per pot. The amount of soil was uniform for all pots and the soil moisture was brought up to 25% at the start of the test, and in the case of the normal water treatment it was maintained approximately at that level throughout the test by bringing the pots to a constant weight at each watering. With the reduced water treatment, the pots were brought up to 25% moisture at each watering but they were only watered half as often. The excess water treatment consisted of maintaining the soil in a water soaked condition throughout the test. The pots were placed in saucers which were filled with water once a day. All treatments were applied from the fourth leaf stage until the first appearance of the panicle on the main tiller. Counts were made only on main tillers. The variety Banner Ott. 49 was used throughout these tests.

In Table 1 is shown the comparative counts of total and blasted spikelets for the three water treatments under field and greenhouse conditions. The field counts are based on 50 plants per treatment, while the greenhouse data are based only on 25.

[2] Since the intensity of light during the winter months is much lower than that normally occurring in summer, normal light under greenhouse conditions is not directly comparable to normal light in the field.

TABLE 1.—INFLUENCE OF DIFFERENT WATER TREATMENTS ON THE PRODUCTION OF BLASTED SPIKELETS

	Total number of spikelets	Number of blasted spikelets	% Blast
Field (50 plants)			
Reduced water	1177	430	36.5
Nomal water	1631	381	23.4
Excess water	1720	333	19.4
Greenhouse (25 plants)			
Reduced water	687	445	64.9
Normal water	749	468	62.6
Excess water	1009	492	49.2

It will be observed from these data that the yield of spikelets per plant is fairly uniform in both field and greenhouse but the percentage blast is much higher under greenhouse conditions. It is further evident that with the application of excess water, the spikelet yield increases and the percentage blast decreases. This is true under both conditions of growth.

TABLE 2.—STATISTICAL ANALYSIS OF DATA FROM TABLE 1

	S.S.	D.F.	M.S.	F.	5% Point	Sig. diff.
Field 1934						
Total spikelet No.						
Between treatments	3,392.57	2	1,696.28			
Within treatments	16,030.20	147	109.05	15.6	3.06	4.18
Blasted spikelets						
Between treatments	94.09	2	47.05			
Within treatments	1,817.00	147	12.36	3.8	3.06	1.41
Percentage blast						
Between treatments	6,590.07	2	3,295.03			
Within treatments	15,700.20	147	106.80	30.8	3.06	4.13
Greenhouse 1933–34						
Total spikelets						
Between treatments	2,335.04	2	1,167.52			
Within treatments	1,230.96	72	17.10	68.3	3.13	2.34
Blasted spikelets						
Between treatments	44.12	2	22.06			
Within treatments	516.55	72	7.17	3.1	3.13	1.5
Percentage blast						
Between treatments	3,594.04	2	1,797.02			
Within treatments	3,196.20	72	44.39	40.5	3.13	3.77

The analysis[3] of these data as summarized in Table 2 shows that in the case of spikelet number under field conditions there is considerable variance due to the water treatments, which, when compared with within treatments (experimental error) gives an F value of 15.6. Referring to Snedecor's (*14*) table XXV "Value of F & t", we find the 5% point, (for $n^1 = 2$ and $n^2 = 150$) to be 3.06, while the 1% point is 4.75, thus the obtained F value is highly significant. Since a difference of 4.18 between any two treatment means is necessary for significance, the reduced water gives a significantly lower number of spikelets than either of the other two treatments. The number of blasted spikelets also shows a significant

[3] The statistical methods employed in this paper are based on those of Fisher (*5*) and Snedecor (*14*).

difference between treatments (F = 3.8) but not so pronounced as in the case of total spikelet number. Here there is little variance within the various treatments, thus the smaller difference required for significance (1.4) between the treatment means. The treatments in the percentage blast analysis show considerable significance (F = 30.8) which is greater than the 1% point. The excess water had a pronounced influence in decreasing the percentage blast, while reduced water had the opposite effect.

Under greenhouse conditions, although there are only half the number of plants in each, the treatments bear the same relationship as found from field data. For total spikelet number F = 68.3 showing significantly that excess water increases spikelet number. The F value for blasted spikelets (3.08) is below the 5% point, thus there is no significance for treatments generally. On the other hand the treatments are responsible for most of the variance in percentage blast, where F = 40.5. The excess water treatment gave results statistically lower than those for either of the other two treatments when considering blast percentages.

Light Treatments

In an attempt to obtain some information concerning the influence of light on oat blast, another series of pots was grown in the greenhouse (1933–34) and subjected to different combinations of light and water treatments. Pots receiving normal, excess and reduced water were grown under normal, excess and reduced light conditions.

The water treatments for this series were similar to those outlined above. In supplying excess light the pots were placed in a properly aerated enclosure and illuminated by a 100 watt Madza light. Apart from the artificial light supplied to the greenhouse generally, this series of pots received light for an additional two hours each night during the course of the experiment. The reduced light series of pots was protected from artificial greenhouse light by a box similar to the one noted above. In both cases the boxes were removed during the day. The pots receiving normal light were left exposed to the light conditions of the greenhouse, which included artificial light from 6 p.m. until 12 p.m. except in the early stages of growth when the duration of artificial light was 2 hours shorter.

Twenty-five plants were grown in each treatment, the main tiller only being used for blast determinations.

In Table 3 are shown the counts of total and the proportion of blasted spikelets for the three light treatments when subjected to reduced, normal and excess water conditions.

Table 3.—Light as a factor in the production of blasted spikelets

	Reduced water		Normal water		Excess water	
	Total spikelets	% Blast	Total spikelets	% Blast	Total spikelets	% Blast
Reduced light	1344	66.8	1755	66.1	1948	55.4
Normal light	687	64.9	749	62.6	1009	49.2
Excess light	503	71.2	645	70.6	813	67.3

From these data it is evident that light has had an appreciable influence in the production of oat blast and that normal light, as supplied under the conditions of the experiment, gave a lower percentage blast than either reduced or excess. With the excess water treatment normal light gave a significantly lower percentage blast than either reduced or excess light. Although in both reduced and normal water treatments, normal light gave a lower percentage blast than the other two conditions of light, excess light alone causes this difference to be significant. Excess light was instrumental in producing the highest percentage blast under any condition of moisture, being significantly higher than the percentages from normal light conditions. Treatments of excess water gave significantly lower percentages of blast under the three conditions of light.

Statistical analysis shows that under any water treatment, reduced light increases the total spikelet number above normal light, the F value being highly significant for all three water treatments. On the other hand, excess light has reduced the yield of spikelets under all water treatments, although only significantly so in the case of the reduced water, where the F value is slightly greater than the 5% point. Light has shown the greatest influence in reducing blast when applied normally with excess moisture. Here the mean 49.2% is significantly lower than any of the other eight percentages.

Critical Period for Blast Development

During the winter of 1934-35 further work was undertaken in the greenhouse to determine the critical period during the development of oat plants when moisture has the greatest influence on blast.

This project consisted of four series of pots each series containing 7 lots of 5 pots each. Six lots of the four series, referred to below as A, B, C and D, received the following water treatments. Series A, normal watering throughout the growing period except that each lot of 5 pots recevied a 14-day period of drought at different stages of growth. Series B received a similar treatment except that the 14-day periods were periods of excess watering. Series C received reduced water throughout the growing period except that each lot of 5 pots was subjected to a 14-day period of excess water at a different stage of growth. Series D received excess water throughout the growing season except for 14-day periods, when drought conditions were administered. Lot 7 of each series was treated as a check and received normal watering throughout.

All pots were normal and uniform as regards soil and soil moisture at the start of the experiment. Reduced water treatments consisted of bringing the soil to 15% moisture at each watering. In pots receiving normal watering the soil moisture was raised to 25%. Pots receiving the excess water treatment were set in saucers which were filled with water once a day.

The first 14-day treatment period started when the plants had reached the fourth leaf stage. These treatments were continued for six periods, the plants having reached the shot blade stage when the last treatment was applied. Series D, which had been given excess water throughout the 84-day treatment period, was somewhat less mature than the other series at the end of the test.

In Table 4 are shown the total number of spikelets and the percentage blast for the seven treatments in each of the four series, each treatment of a series representing a different stage of growth.

TABLE 4.—THE CRITICAL PERIOD OF GROWTH DURING THE DEVELOPMENT OF OATS WHEN MOISTURE HAS THE GREATEST INFLUENCE ON BLAST

Stage of growth after 4th leaf stage (14-day periods or treatments)	Series A Normal moisture with periods of drought		Series B Normal moisture with periods of excess water		Series C Reduced moisture with periods of excess water		Series D Excess moisture with periods of drought	
	Total No. spikelets	% Blast	Total No. spikelets	% Blast	Total No. spikelets	% Blast	Total No. spikelets	% Blast
1	724	40.2	769	43.8	588	44.6	1348	68.7
2	601	40.1	962	44.5	930	44.3	1203	62.5
3	651	32.9	1037	44.3	802	52.1	935	51.3
4	748	38.3	662	42.2	474	46.6	1334	57.5
5	732	52.0	743	38.9	492	51.1	1323	52.3
6	765	41.1	793	39.2	471	47.0	1287	48.7
Check (7)	711	36.8	670	32.1	766	39.0	755	29.9

In Series A, which had normal water throughout the test except for the 14-day periods as described above, the application of drought conditions in the fifth treatment or at the fifth 14-day period from the fourth leaf stage increased the amount of blast by 15% over the check or normal water treatment. This figure (52.0%) is statistically significant not only in relation to the check but also to all other treatments in this series. This stage of growth might readily be referred to as the period when drought will have the greatest effect in increasing blast when normal conditions of watering have prevailed during the previous growth of the plants. It is further apparent from the data of Series A in Table 4 that the third treatment is also critical in so far as a drought period affects blast, but at this stage the blast has been greatly reduced. The percentage (32.9) for the third treatment while not significantly lower than the check (treatment 7), is quite significantly lower than all other treatments in this series. One might conclude therefore that there are two critical periods of growth under the conditions of this series, one at the third stage when a 14-day period of drought lowers the blast percentage and one at the fifth stage when drought has the reverse effect. It might be mentioned here that similar results were obtained from work carried on in 1933-34.

The critical period for the total production of spikelets appears to be during the second and third treatments where in Table 4 it is shown that periods of drought have been highly detrimental.

Series B, which received normal watering throughout the test with the exception of 14-day periods of excess water at different stages of growth beginning with the fourth leaf stage, does not appear to have been influenced at any stage during the early growth period. While treatments at all stages gave significantly higher blast percentages than the normally treated check, yet it is again the treatment at the fifth stage that has had the greatest effect in influencing blast percentage. The critical period therefore in the case of excess water treatments is at the fifth stage, which

was also true in Series A. In this case however the tendency of heavy watering periods has been to reduce blast. The treatment of excess water has had a similar influence in stage six; thus it would seem that the added moisture supply affected blast over a wider maturity range than was the case with the reduced water applications in Series A.

Total spikelet number has been significantly increased as a result of periods of excess water during the early stages. This is evident in the second and third treatments. Total yield of spikelets therefore can be greatly influenced by moisture conditions shortly after the fourth leaf stage of growth.

In Series C, where the plants were given reduced water or semi-drought conditions except for 14-day periods of excess water applications at growth stages as described above, the tendency has again been to increase blast when compared with normal moisture conditions. The percentage blast from all treatments is significantly higher than treatment 7, the normally watered check lot. The smallest amount of blast is found in the first two treatments or during the earlier stages of growth. The young plants at this stage were more favourably affected than when more mature. From a statistical standpoint a difference of 4.68 in blast percentage between any two treatment means is significant. This difference indicates first, that all treatments give significantly higher percentages of blast than the check, and second, that stages one and two are significantly lower in blast percentage than stages three or five but not lower than stages four and six. It is difficult to explain the conflicting blast percentages in stages three to six but it seems significant that the least amount of blast occurred during the early growth as a result of the application of excess water at that stage. While the data do not point to any definite period as being critical under the moisture conditions prevailing, yet the indications are that the early growth period is critical in so far as blast reduction is concerned in a crop suffering from drought.

It is evident from the data of Series C that total spikelet number is influenced quite definitely during the second and third stages when compared with the other 14-day periods of excess moisture. Although only period two is significantly greater than the check, the other four 14-day periods produced a lower total spikelet number. This seems to indicate that, except for the critical stages (periods two and three), periods of excess moisture during normally dry conditions materially lessen the yield of oat spikelets.

In Series D the moisture conditions are the reverse of those in Series C, excess water being applied throughout the test except for 14-day periods of drought beginning with the fourth leaf stage of growth. Data on this series in Table 4 show that drought conditions during the first two stages or treatments have influenced blast adversely and that the blast percentages for these stages and particularly the first stage are quite significantly higher than any other. This early growth period might therefore be called the critical period of blast development under the moisture conditions of the series. The reduction in blast has been most effectively lowered in this series by the application of drought during the sixth stage or just before heading. All water treatments give significantly higher percentages of blast than the normal treatment.

The critical stage for total spikelet development is shown to be the third. At this period there is a significant reduction in spikelet number when compared with the other five water treatments, although all treatments yield higher than the check group. Excess water throughout the season even with the set-back brought about by the 14-day drought periods, has tended to raise the total spikelet number above that of other series except in the case of treatments three and six.

Influence of Dates of Seeding on Blast

It has been commonly observed that blast is more prevalent on late sown crops and likewise on late tillers.

In 1934 a preliminary test was conducted to determine the effect of different seeding dates on blast development. Counts were made on plants seeded at four different dates from April 30 to May 15. An analysis of the data for total spikelet number, failed to show any significant difference between the four dates; however, when the percentage blast was considered, there was significance but only between the two extreme dates. That is to say, later seeding gave a significantly higher percentage blast than the earlier sowing. One might be inclined to conclude further that this test bears out the previously noted fact, that there is no correlation between total spikelet number and percentage blast.

DISCUSSION

A review of the literature indicates that blast or blindness of oats has been known for considerable time, but its suggested causes have been variable. Thrips, halo blight, light, moisture supply and nutrient deficiencies have been suggested as reasons for blast. First, the idea of thrip infestation was discarded as a logical reason for the injury, and later the halo blight suggestion was discarded as an inadequate solution.

More recently evidence has been submitted which associates blast injury with moisture, light and nutrition and further that genetic differences between varieties exist. These differences indicate the possibility of breeding for blast resistance.

The chief objects of the investigations reported in this paper have been to determine the optimum conditions of moisture and light which favour the maximum production of fertile spikelets and to find at what stage of growth the oat plants are most susceptible to adverse conditions of growth, in so far as blast is concerned.

Various water treatments were investigated from which it was shown that under both field and greenhouse conditions excess moisture lowered the percentage blast, although only under conditions in the greenhouse is this difference significant when compared with the normal water treatment. Excess water treatments produced the greatest number of spikelets under both conditions but again this difference is only significantly greater in the case of normal moisture treatment under greenhouse conditions. It would seem that the stage at which the moisture was applied to the oat plant has an influence on both spikelet number and percentage blast. Huskins (*4*) suggested that resistance to blast may be combined with high spikelet number per panicle, and concluded "that specific genetic resistance to blindness exists, and that differences in degree of blindness

are not due to a general physiological correlation with panicle size." Data from the investigations herein reported show a −.0129 correlation coefficient for percentage blast and total spikelet number when the significant level is .159.

Elliott (*2*) observed that blast percentage was associated with precipitation during the month of heading. These observations are confirmed in the present paper and from data presented in Table 4 it is clear that there are critical periods at which the moisture supply influences both the percentage blast and total spikelet number. These periods vary according to the conditions of moisture that the plant has passed through during the earlier stages of growth. A sudden period of either excess moisture or drought during a stage when the young oat panicle is beginning to differentiate would greatly influence its subsequent yield, favourably in the case of added precipitation and unfavourably where the drought condition exists. These results seem to indicate that the critical period is about six or eight weeks after seeding, depending upon the prevailing climatic conditions.

Rademacher (*12*) showed that light was also a causal factor in blast production. The investigations herein discussed have confirmed these findings and have shown that reduced light tends to increase spikelet number under any condition of moisture but is effective in reducing blast only when compared with excess light and particularly under excess water treatment. Normal light produces the lowest percentage blast under any water treatment, but here again the difference is only significant under heavy water applications. Excess light gave the lowest spikelet number, this influence being significantly effective only in the case of reduced water application. Blast percentage was increased quite considerably by excess light under any water treatment. From a practical standpoint it would seem that cool cloudy weather six to eight weeks after seeding in the field has a tendency to increase the yield of spikelets, but the moisture supply interacts with the light conditions to produce varying percentages of blast. The combination of normal light conditions with excess moisture supply favours the reduction of blasted spikelets.

Rademacher (*11*) has pointed out that there is a direct relationship between date of seeding and blast percentage. Late seeding was shown to produce the highest percentage of blast. This conclusion has been confirmed from data obtained during the course of this investigation and while the interval between the first and last seeding was only fifteen days, yet there was a significant difference in blast percentage between the extreme seedings. When seeded late, there is ordinarily a forced, rapid growth on account of the higher temperatures. The critical period for blast development will, under these conditions, more likely fall during a drier, hotter period than would be the case with early seeding. Such conditions of environment, as shown in Series A, Table 4, favour blast development at certain stages of growth. It is assumed therefore that in delaying the critical period for blast development by late seeding, more favourable conditions exist for the blasting of those late maturing spikelets that otherwise might have developed normally under the environment of earlier seeding.

SUMMARY

1. Moisture is an important factor in blast development. The application of excess water is most effective in reducing blast under both field and greenhouse conditions.

2. Light, a factor in blast reduction, is most effective when applied normally, and particularly when combined with excess water.

3. The critical period for blast development, as shown by the influence of water and light, appears to be from six to eight weeks after seeding, this period varying with the moisture supply.

4. Late seeding increases blast production. It has also been observed that late tillers are more susceptible to conditions favouring blast.

5. Statistical analysis shows no significant correlation between percentage blast and total spikelet number.

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Résumé

Une étude des causes de la "Coulure" (Blast) de l'avoine. R. A. Derick et J. L. Forsyth, Ferme expérimentale centrale, Ottawa, Ont.

L'humidité est un facterur important dans le développement de la coulure. L'application d'une quantité excessive d'eau aide beaucoup à réduire la coulure, aussi bien dans les conditions de pleine terre que dans celles de la serre. La lumière, qui est un facteur dans la réduction de la coulure, est surtout utile lorsqu'elle est appliquée normalement, et spécialement lorsqu'elle est combinée avec un excès d'eau. La période critique pour le développement de la coulure, démontrée par l'effet de l'eau et de la lumière, paraît être de six à huit semaines après les semailles; elle varie avec la proportion d'humidité. Les semailles tardives augmentent la coulure. On a remarqué également que les plantes tallant tard sont plus sensibles aux conditions qui favorisent la coulure. L'analyse statistique n'indique aucune corrélation significative entre le pourcentage de coulure et le nombre total d'épillets.

A SIMPLE METHOD OF HEAD THRESHING[1]

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A simple and rapid method for threshing single heads or panicles of cereals and grasses has been developed. This method promises to be very useful wherever it is necessary to keep separate the seed of a single inflorescence or plant.

A diagram of the apparatus is shown in Figure 1. It consists of a piece of used bicycle tubing (A) 16 inches long, which slips over a grooved collar. Used bicycle tubing has been found to be more satisfactory than new tubing since the latter is usually flattened and creased. Between the

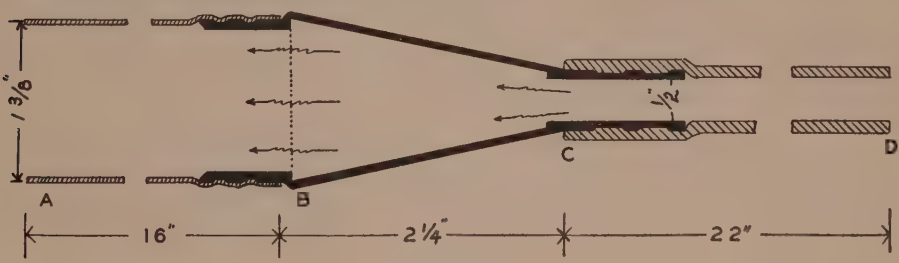

Figure 1.

grooved collar and the funnel a 60-mesh brass woven-wire screen is soldered in place (B. Figure 1). This serves to equalize the air flow over the area of the opening. The small end of the funnel is connected by 22 inches of rubber tubing to a cock on a compressed air line.

In one of the tests, a portable air compressor operated by a $\frac{3}{4}$-horse power motor was used to provide the necessary air flow for satisfactory cleaning. This was obtainable with pressures as low as 15 pounds. Since this machine is capable of giving pressures of 200 pounds, a smaller unit should serve the purpose. The air line serving the laboratories, which carries a pressure of 80 pounds, was used in another test with excellent results. The initial air flow was reduced and set by means of a needle valve. Final control during threshing was obtained with an ordinary lever-armed valve. While the above tests indicate that hand control of widely different pressures is satisfactory, the installation of an automatic pressure reducing valve might be advantageous. If a suitable compressor is not available, it is probable that the air flow provided by a small multi-blade blower fan or a domestic vacuum cleaner fan would be satisfactory.

The heads or panicles are threshed inside the bicycle tubing by rubbing with a rolling motion against a smooth flat surface. The bicycle tubing is then held up at a suitable angle and the air turned on. By shaking the

[1] Contribution from the Division of Biology and Agriculture, National Research Laboratories, Ottawa.
[2] Biologist.

apparatus and varying the angle and air flow any refinement of separation can be readily obtained. The air pressure combined with the shaking keeps the seeds agitated and permits the chaff to be quickly carried out of the end of the tube. The air is then turned off and the clean seeds emptied into an envelope. This method has been found to work equally as well with heavy grains such as wheat, oats, barley, and rye as with the light seeded grasses such as timothy and red top. Difficulty may be experienced in inserting large widely branched panicles in the size of tubing illustrated. For crops possessing this type of inflorescence a larger threshing tube would probably be more suitable.

Where head threshing methods are necessary it is usually very important to reduce threshing damage to the minimum. This appears to be possible with this method as evidenced by the fact that oats can be threshed without breaking off the dorsal arm, and barley with little danger of breaking the hull.

Tests on the rate of threshing with barley have shown that one person can thresh over 200 heads an hour providing the clipped heads are ready and no time is allowed for labelling. This rate is the same as that calculated for the head threshing machine developed by Kemp (*1*).

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THE ECONOMIC SITUATION

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, LARGELY FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

The index number of wholesale prices in Canada declined from 72.3 in May to 71.5 in June. The index of vegetable product prices dropped from 68.0 to 66.1. Animals and their products fell from 69.5 to 68.7. Non-ferrous metals and their products declined from 70.7 to 69.6. Less striking recessions occurred in iron and its products, and fibres, textiles and textile products. Gains were reported in the wood, wood products and paper group as well as in non-metallic minerals.

Retail Prices.—The index of retail prices was unchanged in June. The index of food prices was slightly higher, that of clothing was slightly lower and prices of fuel were noticeably less than in May.

The value of retail sales was well maintained in June, the index being 71.8 compared with 72.4 in May and 72.6 in June of last year. The decline in June was less than in any of the previous four years. The lower level in June of this year could be explained by the fact that there was one less selling day during the month of June 1935 than in June 1934. The May to June change in 1935 represented a decline of 0.8%. In 1934, the change was 3.6% downward while in 1933 it was 2.5% and in 1932, 2.6%.

Physical Volume of Business.—The index of the physical volume of business reached a high point of 103.2 in May. This level was not maintained in June but business was still at a high level the index being 99.2. Industrial production showed a similar decline for the index dropped to 99.7. Mineral production was down nearly five points. Shipments of silver were somewhat higher but those of gold were considerably lower, and coal production was under that of May.

The index of manufacturing dropped from 105.1 to 98.4. There was a slight increase in manufacture of sugar, imports of textiles, particularly those of cotton and wool, were higher than during the previous month. Exports of shingles were considerably above those of May. Pig iron production was higher. Steel production advanced about three points. Construction also showed improvement and the index rose from 38.1 to 43.7. Trade employment was slightly higher than in May. Car loadings were lower and both exports and imports were down.

Generally speaking, there was a general easing down in production which was responsible for the decline in the index.

Among the agricultural factors, grain marketings were substantially above those in May, the index rising from 85.4 to 112.3. All classes of grain moved in larger volume. The index of live stock marketings moved downward from 90.6 to 78.2. There was, however, a large gain in marketings of calves.

Cold Storage Holdings.—The index of cold storage holdings as of June 1 was slightly higher than as of May 1. This was due to the increased stocks of beef, mutton, pork and lard. There were substantial reductions in eggs, butter, cheese, poultry and meat.

Prices of Agricultural Products.—The index number of wholesale prices of Canadian farm products showed the first sharp decline in some months, falling from 64.1 to 61.4. The index prices of field products dropped from 58.0 to 55.1. The average price of No. 1 Manitoba Northern wheat was 85.7 cents per bushel in May compared with 81.7 in June. No. 2 C. W. oats declined from 40.8 to 39.8. No. 2 C. W. rye fell from 46.0 to 41.2. No. 3 C. W. barley averaged 39.2 cents per bushel in June which represented a decline of 3.1 cents per bushel. The index of prices of animal products declined from 74.2 to 72.0. Prices generally were lower although

ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION COMPUTED BY DOMINION BUREAU OF STATISTICS

Year	Wholesale Prices 1926 = 100				Retail prices and cost of services (5)	Production (6) 1926 = 100			
	All commodities (1)	Farm products (2)	Field products (3)	Animal products (4)		Physical volume of business	Industrial production	Agricultural marketings	Cold Storage holdings
1913	64.0	62.6	56.4	77.0	65.4				
1914	65.5	69.2	64.9	79.0	66.0				
1915	70.4	77.7	76.9	79.2	67.3				
1916	84.3	89.7	88.4	92.3	72.5				
1917	114.3	130.0	134.3	119.6	85.6				
1918	127.4	132.9	132.0	134.7	97.4				
1919	134.0	145.5	142.4	152.5	107.2	71.3	65.5	48.1	47.1
1920	155.9	161.6	166.5	149.9	124.2	75.0	69.9	52.6	94.2
1921	110.0	102.8	100.3	108.5	109.2	66.5	60.4	65.2	86.4
1922	97.3	86.7	81.3	99.1	100.0	79.1	76.9	82.6	82.8
1923	98.0	79.8	73.3	95.1	100.0	85.5	83.8	91.4	87.6
1924	99.4	87.0	82.6	97.2	98.0	84.6	82.4	102.5	114.9
1925	102.6	100.4	98.1	105.7	99.3	90.9	89.7	97.2	108.6
1926	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1927	97.7	102.1	99.9	105.7	98.4	106.1	105.6	103.6	110.0
1928	96.4	100.7	92.6	114.3	98.9	117.3	117.8	146.7	112.8
1929	95.6	100.8	93.8	112.5	99.9	125.5	127.4	101.1	109.6
1930	86.6	82.3	70.0	102.9	99.2	109.5	108.0	103.0	128.4
1931	72.2	56.3	43.6	77.6	89.6	93.5	90.4	99.0	125.7
1932	66.7	48.4	41.1	60.7	81.4	78.7	74.0	114.3	120.1
1933	67.1	51.0	45.8	59.6	77.7	79.7	76.8	105.1	115.4
1934	71.6	59.0	53.9	67.6	78.9	94.2	93.6	88.5	114.2
1934									
Jan.	70.6	55.3	47.9	67.8	78.2	86.8	84.5	48.2	108.1
Feb.	72.1	58.0	49.3	72.5	78.7	86.4	84.0	67.1	98.6
Mar.	72.0	56.5	49.5	68.3	79.9	93.1	92.0	63.8	97.0
Apr.	71.1	55.4	48.7	66.6	79.4	92.6	91.4	56.9	94.5
May	71.1	56.9	51.1	66.5	78.5	99.6	99.4	130.6	102.6
June	72.1	59.3	55.5	65.6	78.2	95.8	95.2	97.2	126.1
July	72.0	60.0	57.8	63.7	78.4	95.7	95.6	148.8	116.3
Aug.	72.3	61.6	60.7	63.1	78.7	99.0	99.8	172.8	114.7
Sept.	72.0	61.3	58.9	65.3	79.0	97.1	97.5	127.7	117.7
Oct.	71.4	60.9	55.3	70.4	79.3	95.8	95.3	61.2	128.8
Nov.	71.2	61.2	55.7	70.4	79.4	96.5	97.0	51.2	130.4
Dec.	71.2	61.6	56.0	70.9	79.0	92.4	91.0	36.0	135.7
1935									
Jan.	71.5	61.4	55.7	71.0	78.9	97.5	97.8	30.6	143.7
Feb.	71.9	62.0	55.7	72.6	79.1	100.6	101.1	62.2	141.2
Mar.	72.0	62.7	56.4	73.3	79.0	94.2	93.3	65.4	143.2
Apr.	72.5	64.7	59.8	72.9	78.8	98.3	97.7	91.8	135.8
May	72.3	64.1	58.0	74.4	78.7	103.2	104.4	86.3	123.2
June	71.5	61.4	55.1	72.0	78.7	99.2	99.7	106.1	125.0

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1933, p. 15.

2. Wholesale prices of Canadian products of arm origin only. See Prices and Price Indexes 1913-1933, p. 33, and Monthly Mimeographs 1933 and 1934.

3. Wholesale prices of grains, fruits and vegetables.

4. Wholesale prices of Animals and Animal Products.

5. Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926 = 100.

Prices and Price Indexes 1913-1931, p. 108, and Monthly Mimeographs 1933-1934.

6. Monthly Review of Business Statistics, p. 8, and Monthly Indexes of the Physical Volume of business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

hogs were higher and good handyweight lambs averaged higher prices at Toronto than was the case during May. Prices of butter were lower while those of eggs were higher in principal markets.

Prices in Great Britain.—The monthly index of prices of agricultural produce (corresponding months 1911 — 13 = 100) was 111 in May compared with 119 in April. Seasonal trends are given as a partial explanation of the decline. Prices of fat cattle and potatoes were considerably better, but the price of milk was lower because of the adjustment in the regional contract price to the summer level. Prices of butter were slightly lower but cheese was higher. Eggs were also higher than in April but ducks and fowls were cheaper. Bacon pigs were lower.

United States Prices.—Index numbers of farm prices in United States (August 1909, July 1914 = 100) were 4 points lower than in May, the index declining from 108 to 104. Prices of fruits and meat animals advanced but indexes of other commodities declined. In the case of grains, the index fell from 112 to 102. Cotton and cottonseed declined from 105 to 103. Truck crops dropped from 127 to 96. Dairy products lost 7 points, the index for June being 100. The index of prices of chickens and eggs declined from 110 to 108. Prices paid by farmers for commodities bought were unchanged but the ratio of prices received to prices paid was 82 compared with 85 in May.

LA SITUATION ÉCONOMIQUE

PRÉPARÉ PAR LA DIVISION DE L'ÉCONOMIE AGRICOLE, MINISTÈRE DE L'AGRICULTURE, OTTAWA, PRINCIPALEMENT D'APRÈS LES DONNÉES RECUEILLIES PAR LE BUREAU FÉDÉRAL DE LA STATISTIQUE

Le chiffre-indice des prix du gros au Canada qui était à 72.3 en mai est tombé à 71.5 en juin. L'indice des prix des produits végétaux a rétrogradé de 68.0 à 66.1; celui des animaux et leurs produits de 69.5 à 68.7, et celui des métaux non ferreux et leurs produits de 70.7 à 69.6. Il y a eu d'autres régressions moins fortes dans le fer et ses produits et dans les fibres, textiles et produits textiles. D'autre part, on signale des gains dans le bois, le groupe des produits du bois et du papier ainsi que dans les minéraux non métalliques.

Prix du détail.—L'indice des prix du détail n'a pas changé en juin. L'indice des prix des aliments était un peu plus élevé, celui des vêtements un peu plus bas et les prix du combustible sensiblement moins élevés qu'en mai.

La valeur des ventes au détail a été bien maintenue en juin; l'indice était de 71.8 contre 72.4 en mai et 72.6 en juin de l'année dernière. La diminution de juin est la plus faible que l'on ait enregistrée depuis quatre ans. Le niveau plus bas constaté en juin peut s'expliquer par le fait qu'il y a eu un jour de vente de moins pendant le mois de juin 1935 que pendant le mois de juin 1934. Les changements de mai à juin en 1935 représentent une diminution de 0.8 pour cent. En 1934, la diminution avait été de 3.6 pour cent, en 1933 de 2.5 pour cent et en 1932 de 2.6 pour cent.

Volume physique des affaires.—L'indice du volume physique des affaires a atteint le point élevé de 103.2 en mai. Ce niveau n'a pas été maintenu en juin mais l'indice est resté assez élevé, 99.2. La production industrielle accusait une diminution semblable car l'indice est tombé à 99.7. La production minérale a baissé de près de cinq points. Les expéditions d'argent étaient un peu plus fortes mais celles d'or beaucoup plus faibles et la production de charbon était inférieure à celle de mai.

L'indice des industries manufacturières est tombé de 105.1 à 98.4. Il y a eu une légère augmentation dans la fabrication du sucre; les importations de matières textiles, spécialement de coton et de laine, ont été plus considérables que pendant le mois précédent. Les exportations de bardeaux ont été sensiblement plus élevées qu'en mai. La production de fer en gueuse a été plus forte. La production de l'acier a avancé d'environ trois points. L'indice du bâtiment s'est aussi un peu amélioré, passant de 38.1 à 43.7. L'emploi dans le commerce a été un peu plus élevé qu'en mai, cependant les chargements de wagons ont diminué et il y a eu diminution dans les exportations aussi bien que dans les importations.

Parlant d'une façon générale on peut dire qu'il y a eu un léger fléchissement de la production, qui a provoqué la baisse de l'indice.

Parmi les facteurs agricoles, les ventes de grain ont été bien supérieures à celles de mai, l'indice passant de 85.4 à 112.3. Les expéditions de toutes les catégories de grains ont été plus fortes. L'indice des ventes du bétail est descendu de 90.6 à 78.2; il y a eu cependant une forte augmentation dans les ventes de veaux.

Stocks conservés au froid.—Au 1er juin l'indice des stocks conservés au froid était un peu plus élevé qu'au 1er mai à cause de l'augmentation des stocks de bœuf, de mouton, de lard et de saindoux. Il y a eu des diminutions sensibles dans les stocks d'œufs, de beurre, de fromage, de volailles et de viande.

Prix des produits agricoles.—Le chiffre-indice des prix de gros des produits agricoles canadiens a accusé la première baisse sensible qui ait été enregistrée depuis quelques mois; il est tombé de 64.1 à 61.4. L'indice des prix des produits des champs est tombé de 58.0 à 55.1. En juin le prix moyen du blé du nord Manitoba N° 1

était de 81.7c. le boisseau contre 85.7c. en mai. L'avoine N° 2 C.O. est tombée de 40.8 à 39.8 le seigle N° 2 C.O. de 46.0 à 41.2. L'orge N° 3 C.O. était en moyenne à 39.2c. le boisseau en juin, représentant une diminution de 3.1c. par boisseau. Le chiffre-indice des prix des produits des animaux est tombé de 74.2 à 72.0. Les prix en général étaient plus bas, mais les porcs étaient plus élevés et les agneaux d'un bon poids ont obtenu en moyenne de meilleurs prix à Toronto qu'en mai. Les prix du beurre ont diminué tandis que ceux des œufs se sont relevés sur les principaux marchés.

Prix en Grande-Bretagne.—L'indice mensuel des prix des produits agricoles pour les mois correspondants (1911 — 13 = 100) était à 111 en mai contre 119 en avril. Cette diminution s'explique en partie par les tendances saisonnières. Les prix des bœufs gras et des pommes de terre étaient bien meilleurs mais le prix du lait a diminué à cause de l'ajustage du prix régional de contrat au niveau de l'été. Les prix du beurre étaient un peu plus bas mais ceux du fromage plus élevés. Les œufs se vendaient également plus cher qu'en avril mais les canards et les volailles étaient meilleur marché. Les porcs à bacon étaient plus faibles.

Prix aux Etats-Unis.—Les chiffres-indices des prix des produits de ferme aux Etats-Unis (août 1909, juillet 1914 = 100) étaient de 4 points plus bas qu'en mai; l'indice tombant de 108 à 104. Les prix des fruits et des viandes ont augmenté tandis que les indices des autres produits diminuaient. L'indice des grains est tombé de 112 à 102, celui du coton et de la graine de coton de 105 à 103. Les récoltes maraîchères ont passé de 127 à 96. Les produits laitiers ont perdu 7 points; l'indice pour juin est de 100. L'indice des prix des poulets et des œufs a baissé de 110 à 108. Les prix payés par les cultivateurs pour les marchandises qu'ils achetaient sont restés les mêmes, mais la relation entre les prix reçus et les prix payés n'était que de 82 contre 85 en mai.

AUTHOR INDEX